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Related to the Silicate Industries

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HEADQUARTERS

Gettysburg

HEADQUARTERS of the opposing generals at the battle of Gettysburg, one of the decisive engagements of the civil war. General Lee, of the Confederate Army, directed his troops from the stone house; the commander of Union Army, General Meade, issued orders from the house shown in the lower picture.

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Vol. 8 **December, 1925** **No. 12**

ORIGINAL PAPERS

ANALYSIS OF RECENT MEASUREMENTS OF THE VISCOSITY OF GLASSES.—II[1]

By G. S. Fulcher

ABSTRACT

Viscosity of two series of four component glasses.—The results recently reported by S. English[2] are here analyzed by the method used in a previous paper.[3] (1) *Series* $6SiO_2$, $1.2Na_2O$, $0.8(CaO+MgO)$. The temperature at which the difference between the viscosity of a glass and the viscosity of $6SiO_2,2Na_2O$ at the same temperature makes a sharp bend is called the aggregation temperature T_A. It seems to correspond to the devitrification temperature. For this series T_A reaches a sharp minimum for the composition $6SiO_2$, $1.15Na_2O$, 0.45MgO, 0.39CaO. The viscosity for any temperature also reaches a minimum at or near this composition. (2) *Series* $6SiO_2$, $1.1Na_2O$, $0.9(CaO+Al_2O_3)$. The curves are similar to those for the first series, T_A reaching a sharp minimum for the composition $6SiO_2$, $1.11Na_2O$, 0.81CaO, $0.14Al_2O_3$.

Introduction

Since the first paper on this subject was written,[3] English has published his results for two series of four component glasses.[2] The method used in analyzing the data for the three component glasses has now been applied to these later results.

Soda-Lime-Magnesia-Silicate Glasses

The molecular compositions of these glasses are given in Table VIII, taking the total number of molecules as 8 since the glasses are formed by

[1] Recd. Oct. 5, 1925.

[2] S. English, *Jour. Soc. Glass Tech., Trans.*, **9** [6], 83 (1925).
[3] G. S. Fulcher, *Jour. Amer. Ceram. Soc.*, **8** [6], 339 (1925).

the molecular substitution of MgO for CaO in the glass $6SiO_2$, $1.2Na_2O$, $0.8CaO$—more accurately $6SiO_2$, $1.15Na_2O$, $0.84CaO$.

TABLE VIII

MOLECULAR COMPOSITIONS OF SERIES OF Na_2O-CaO-MgO-SiO_2 GLASSES

Glass number	9	490	491	492A	493	494	331
SiO_2	5.991	5.967	5.942	5.958	6.033	5.978	5.975
Na_2O	1.153	1.148	1.154	1.106	1.117	1.142	1.191
CaO	.802	.644	.548	.463	.324	.265	.012
MgO	.034	.197	.308	.433	.486	.573	.803
Al_2O_3	.020	.044	.048	.040	.040	.042	.019
$SiO_2 + Al_2O_3$	6.011	6.011	5.990	5.998	6.073	6.020	5.994
CaO + MgO	.836	.841	.856	.896	.810	.838	.815
Excess (CaO + MgO)	− .004	+ .001	+ .016	+ .056	− .030	− .002	− .025
$(SiO_2 + Al_2O_3)/(RO + R_2O)$	3.02	3.02	2.98	3.00	3.15	3.04	3.01

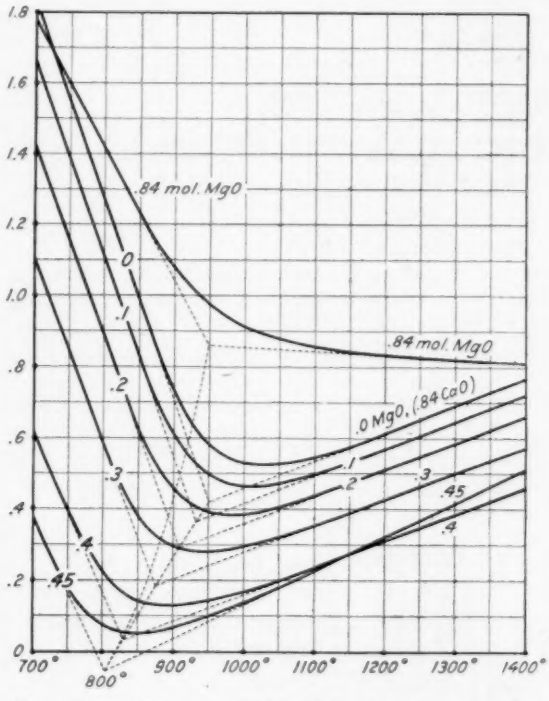

FIG. 17.—$\Delta \log_{10} \eta$ as a function of temperature for a series of glasses $6SiO_2$, $1.15Na_2O$, $0.84(CaO + MgO)$ for 0 to 0.45 molecule MgO, and for 0.84 molecule MgO, as indicated.

From the logarithmic viscosities given by English for these glasses were subtracted the values for the simple trisilicate (glass 1E) for the same temperatures, obtained from a large scale drawing of Fig. 5 (previous article). These differences were plotted as a function of temperature, smooth curves were drawn through the experimental points, and from these the values for certain even temperatures (750°, 800°, etc.), were read. These smoothed results were then corrected for the excess of the amount of (CaO + MgO) substituted for Na_2O over 0.84, the assumed corrections per molecule (obtained by plotting change of $\log_{10} \eta$ as a function of CaO for various temperatures, cf. Fig. 6, and determining the slope at 0.84 molecule CaO) being as follows:

Temp.	700°	750°	800°	850°	900°	1000°	1100°	1200°	1400°
Corr./mol.	4.3	4.0	3.7	3.35	2.95	1.75	1.20	1.25	1.40

Correction was also made for the excess of the ratio of (SiO_2 + Al_2O_3) to (Na_2O + CaO + MgO) over 3.00, assuming the following values for the correction per unit difference (obtained from Fig. 2):

Temp.	700°	750°	800°	900°	1000°	1100°	1200°	1400°
Corr./diff.	0.70	0.64	0.60	0.54	0.50	0.46	0.43	0.38

No correction was made for the substitution of Al_2O_3 for SiO_2. Since both excess (CaO + MgO) and excess SiO_2 increase the viscosity, the observed change in $\log_{10}\eta$ is too large in each case, therefore the correction in each case is negative.

The corrected differences for certain constant temperatures were next plotted as a function of MgO content. The values for glass 490 seem about 0.1 too low while those for 491 seem about 0.1 too high to fit in with the other points. Assuming this discrepancy to be due to experimental error (as does English), smooth curves were drawn through the points including values for 0.84 molecule MgO obtained from Fig. 12. From these the values for 0, 0.1, 0.2, etc., molecule MgO were determined. These values, somewhat adjusted to give a consistent family of curves, are plotted in Figs. 17 and 18.

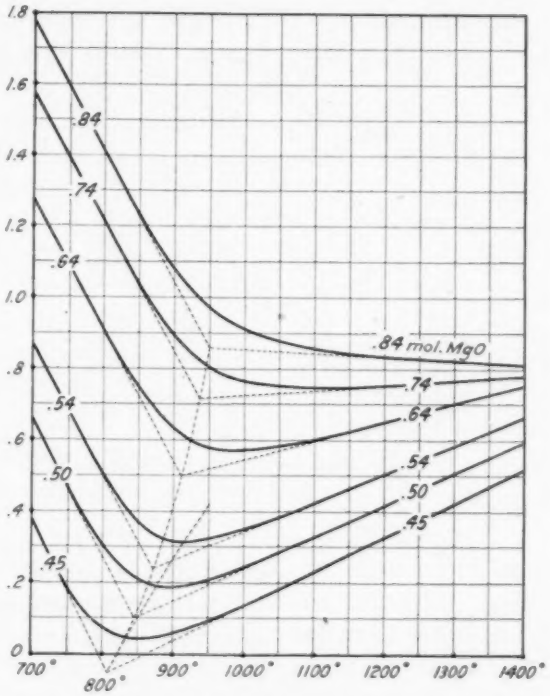

FIG. 18.—$\Delta \log_{10}\eta$ as a function of temperature for a series of glasses $6SiO_2$, $1.15Na_2O$, $0.84(CaO + MgO)$ for 0.45 to 0.84 molecule MgO, as indicated.

These curves are of the same type as those of Figs. 6, 12 and 14, each consisting of two apparently straight parts joined by a curve. The temperature at which the straight parts (extended) for each curve intersect, will be called, as before, the aggregation temperature T_A for that glass.

The most striking result of the analysis is the way in which this temperature T_A decreases to a sharp minimum (Fig. 19) for a ratio of MgO to CaO of $0.445/(0.84-0.445) = 1.13$, which is very close to the eutectic ratio for the oxides as determined at the Geophysical Laboratory, $1.24 = 0.465/(0.84-0.465)$. This agreement is probably accidental as the eutectic or boundary composition must be between two silicates.

The effect of substituting 0 to 0.45 molecule MgO for CaO in the glass $6SiO_2$, $1.15Na_2O$, 0.84CaO, is to shift the whole viscosity curve (Fig. 17) to the left and down, decreasing the low temperature slope slightly. The effect of substituting 0 to 0.39 molecule CaO for MgO in the glass $6SiO_2$, $1.15 Na_2O$, 0.84MgO (Fig. 18), is likewise to shift the curves to the left and down, increasing the high temperature slope considerably and the low temperature slope only slightly. Glasses with about the eutectic compo-

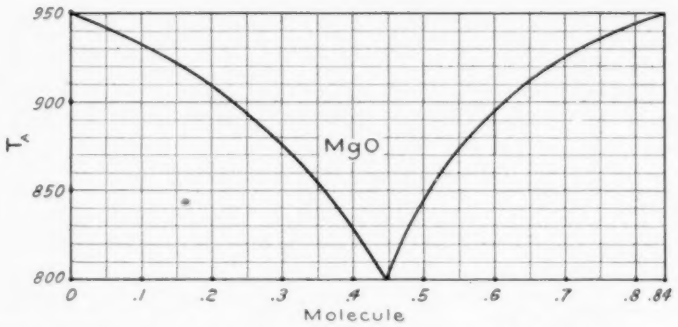

FIG. 19.—Aggregation temperature for $6SiO_2$, $1.15Na_2O$, $0.84(CaO + MgO)$ as a function of MgO content.

sitions have above the temperature of minimum $\Delta \log \eta$ (850° to 950°) a less change of viscosity with temperature than the trisilicate $6SiO_2$, $2Na_2O$ with which these glasses are compared, but at lower temperatures the change of viscosity is much greater and intermediate between that due to substitution of 0.84MgO and that due to substitution of 0.84CaO.

Soda-Lime-Alumina-Silicate Glasses

The molecular compositions of these glasses are given in Table IX, taking the total number of molecules as 8 as before, since the glasses are formed by the molecular substitution of Al_2O_3 for CaO in the glass $6SiO_2$, $1.11Na_2O$, 0.95CaO.

As in the case of the preceding series, the increase of $\log_{10} \eta$ due to the substitution of $(CaO + MgO + Al_2O_3)$ for Na_2O in the trisilicate, was determined for each reading given by English. The smoothed results at

TABLE IX

MOLECULAR COMPOSITIONS OF SERIES OF Na_2O-CaO-Al_2O_3-SiO_2 GLASSES

	10	460	459	458
SiO_2	5.955	5.967	6.048	6.098
Na_2O	1.100	1.056	1.004	.931
CaO	.888	.839	.689	.627
MgO	.036	.011	.018	.000
Al_2O_3	.021	.127	.250	.345
(CaO + MgO + Al_2O_3)	.945	.977	.957	.972
Excess (RO + R_2O_3)	— .005	+ .027	+ .007	+ .022
$SiO_2/(8-SiO_2)$	2.91	2.93	3.09	3.21

various even temperatures were corrected first for substitution of MgO for CaO using the following values (obtained from Fig. 17):

Temp.	700°	800°	850°	900°	950°	1000°	1100°	1400°
Corr./mol.	1.40	1.40	1.35	0.94	0.40	0.20	0.18	0.18

To correct for excess (RO + R_2O_3) the following values were used (obtained as before from the slopes of $\Delta \log_{10} \eta$ as a function of CaO at 0.95 mol. CaO):

Temp.	700°	750°	800°	850°	900°	950°	1000°	1100°	1400°
Corr./mol.	5.6	5.25	4.9	4.6	4.2	3.3	2.5	1.6	1.7

Correction was also made for the excess of the SiO_2 ratio over 2.91.

The corrected values for certain temperatures were plotted as a function of Al_2O_3 content and the smoothed values were plotted as a function of temperature. Fig. 20 gives the results somewhat adjusted to give a consistent family of curves. The values for 0.95 molecule Al_2O_3 were obtained from Fig. 13 by extrapolation. The set of curves obtained is quite similar to the set for substitution of MgO for CaO. The aggregation temperature

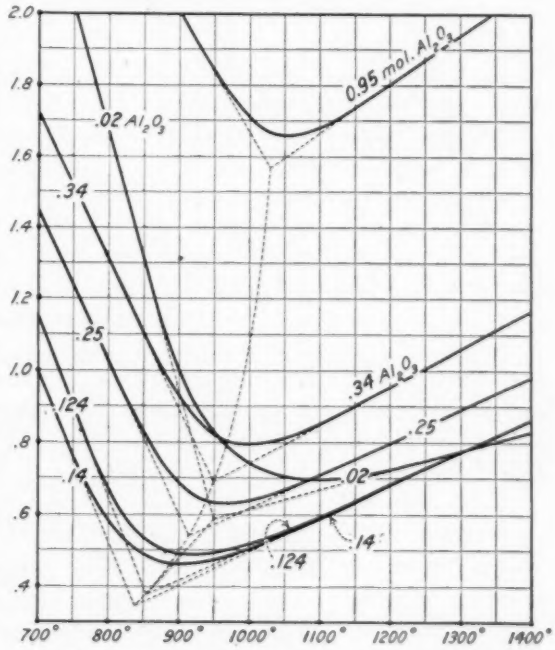

FIG. 20.—$\Delta \log_{10} \eta$ as a function of temperature for a series of glasses $6SiO_2$, $1.11Na_2O$, $0.95(CaO + Al_2O_3)$ containing various molecular amounts of Al_2O_3, as indicated.

(Fig. 21) decreases to a sharp minimum which seems to be for 0.14 molecule Al_2O_3 although this is somewhat uncertain because only four glasses were studied. This composition must correspond to a eutectic between two silicates. There is no eutectic between Al_2O_3 and CaO in this region.

The effect of substituting 0 to 0.14 molecule Al_2O_3 for CaO in the glass $6SiO_2$, $1.11Na_2O$, $0.95CaO$, is to shift the viscosity curve (Fig. 20) to the left and down, increasing the high temperature slope and decreasing the low temperature slope considerably. The effect of substituting 0 to 0.81 molecule CaO for Al_2O_3 in the glass $6SiO_2$, $1.11Na_2O$, $0.95Al_2O_3$, is also to shift the viscosity curve (Fig. 20) to the left and down, decreasing the high temperature slope and increasing the low temperature slope slightly.

The easiest way to obtain the viscosity curve for any composition intermediate between those for which curves are given in Figs. 17, 18 or 20 is to determine the aggregation temperature from Figs. 19 or 21, locate this on the dotted aggregation temperature curve of Figs. 17, 18 or 20, then

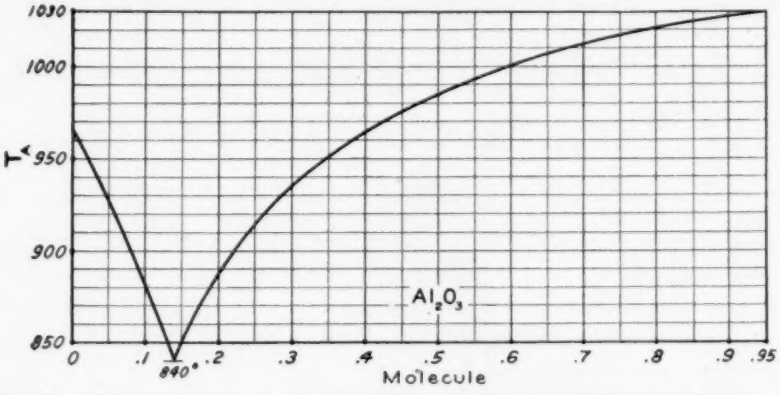

FIG. 21.—Aggregation temperature of $6SiO_2$, $1.11Na_2O$, $0.95(CaO + Al_2O_3)$ as a function of Al_2O_3 content.

draw the high and low temperature lines with slopes intermediate between the two nearest curves and connect them with a curve. To get more accurate results it is necessary to plot $\Delta \log_{10} \eta$ as a function of CaO or Al_2O_3 for various constant temperatures.

The absolute values given in Figs. 17, 18 and 20 may be in error by 0.1 or even 0.2 but the variation of the curves with composition probably corresponds, at least qualitatively, with that indicated by the figures. It would be of interest to determine by quenching experiments whether the compositions $6SiO_2$, $1.15Na_2O$, $0.45MgO$, $0.39CaO$ and $6SiO_2$, $1.11Na_2O$, $0.81CaO$, $0.14Al_2O_3$ actually do correspond to eutectics.

CORNING GLASS WORKS
CORNING, N. Y.

A METHOD FOR TESTING THE CROSS-BENDING STRENGTH OF ENAMELS[1]

By R. R. Danielson and W. C. Lindemann

ABSTRACT

Methods which have been proposed for measuring the strength of enamels, by means of impact tests, are not entirely applicable to enameled flat ware, where the ordinary strains are due to bending of the sheets. An apparatus has been devised by means of which bending stresses can be applied in gradually increasing increments so that the normal behavior of enamels under such stresses can be observed and measured.

Introduction

The subject of strength of vitreous enamels is always one of extreme interest and several methods for determining the strength have been proposed. A method for testing the resistance of kitchen ware enamels to impact has been described by Landrum[2] in which a five-pound weight is dropped a distance of $20^1/_4$ inches onto the ware. Various modifications of the impact test have also been suggested by Orton[3] and by Danielson and Sweely.[4]

It will be noted that all these methods are concerned with the resistance of enamels to impact and this is natural since the type of ware to which these tests have been mainly applied usually fail because of stresses received in impact. Such articles, however, as signs and stove parts in the form of flat sheets, probably fail in most cases because of the excessive flexing of the sheets during handling. This type of failure is, therefore, of interest to manufacturers of this class of ware because of breakage encountered at times in the assembling and mounting of enameled parts, and also because of the natural desire to produce ware which will be as free as possible from any inherent tendencies of this sort. How to determine quantitatively, and in a reasonable length of time, what type of enamel or shop practice will give the most satisfactory results in this connection has been a real problem. Bending tests have been suggested but no practical method for applying the load or measuring the flexion has previously been brought forward.

Description of Apparatus

The apparatus shown in Figs. 1, 2 and 3 has recently been constructed for testing the bending strength of porcelain enamels. A transverse load

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[1] Presented at the Annual Meeting, American Ceramic Society, Columbus, Ohio, February, 1925. (Enamel Division.) Received Sept. 24, 1925.

[2] R. D. Landrum, "A Comparison of Ten White Enamels for Sheet Steel," *Trans. Amer. Ceram. Soc.*, **14**, 489 (1912).

[3] E. Orton, Jr., "Testing of Enameled Sheet Steel Wares," *Trans. Amer. Ceram. Soc.*, **11**, 320 (1909).

[4] R. R. Danielson and B. T. Sweely, "Relations between Compositions and Properties of Enamels for Sheet Steel," *Jour. Amer. Ceram. Soc.*, **6** [10], 1011 (1923).

is applied to enameled test plates, 2 x 12 inches and of 22 gage sheet steel. In order to eliminate variations in results due to varying thickness of enamel coating, the test plates are weighed after each coat is applied and fired and only those of a specified weight are used.

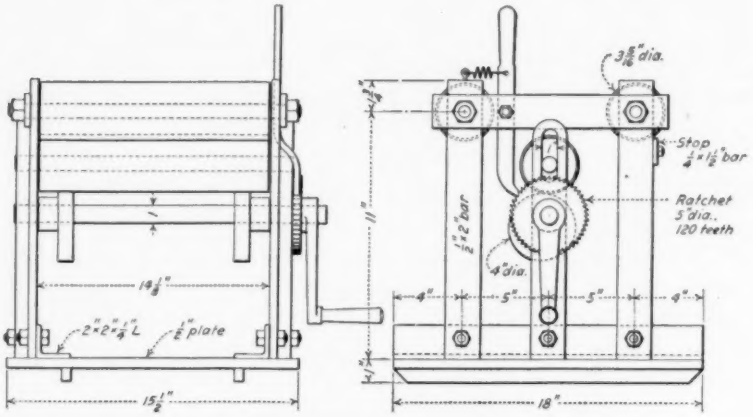

FIG. 1.—Sketch of apparatus for cross-bending tests.

As will be noted in Fig. 3, the test plates are placed against stationary bearing supports made from 3-inch pipe, the load being applied by a movable 3-inch roller fulcrum, which is raised vertically by an eccentric arrangement operated from a ratchet wheel. The 3-inch circular bearing supports prevent sharp bends and also allow for continual readjustment of the bearing points. The two stationary supports are fixed at 10 inches, center to center, with the movable roller halfway between these points. The enameled plates are placed face side up in contact with the fixed supports and the movable roller is raised until in contact with the under side of the plate. Then, by means of the ratchet, the movable roller is raised the desired distance, each notch on the ratchet giving a vertical rise of about $^{3}/_{64}$ inch. This arrangement places the upper enameled surface in tension and also permits of ready observation of progress of failure during the period of test.

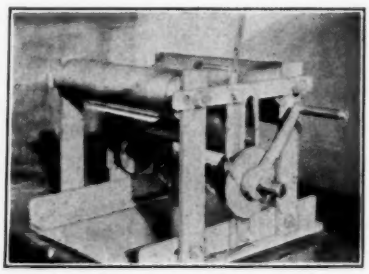

FIG. 2.—View of apparatus showing device for raising movable roller.

In our tests it has been found advisable to make three notches on the ratchet, the initial elevation of the movable roller, and one notch each interval thereafter. These adjustments are made twice each day and ob-

servations are made at each interval for the first appearance of crazing or cracking of the enamel, as well as the point at which the enamel flakes from the plate.

TABLE I

RESULTS OF TESTS ON FOUR WHITE ENAMELS

Date	Hour when observed	No. of notches raised	Condition of Enamels			
			Enamel 1, 31.39% feldspar, 8.86% quartz	Enamel 2, 31.39% feldspar, 10.86% quartz	Enamel 3, 29% feldspar, 12% quartz	Enamel 4, 25% feldspar, 16% quartz
1/8/25	5:30 P.M.	3	Good	Good	Good	Good
1/9/25	8:00 A.M.	.	Good	Good	Good	Good
1/9/25	8:00 A.M.	1	Good	Good	Good	Short fine crack
1/9/25	5:30 P.M.	.	Good	Good	Good	Crack lengthened
1/9/25	5:30 P.M.	1	Good	Good	Good	Crack lengthened
1/10/25	8:00 A.M.	.	Good	Good	Good	Crack across plate
1/10/25	8:00 A.M.	1	Good	Good	Good	Crack across plate
1/10/25	12:30 P.M.	.	Good	Good	Good	Enamel flaked
1/10/25	12:30 P.M.	1	Fine crack	Good	Good	Enamel flaked
1/12/25	8:00 A.M.	.	Crack across plate	Fine crack	Good	Enamel flaked
1/12/25	8:00 A.M.	1	Enamel flaked	Enamel flaked	Good	Enamel flaked
1/12/25	5:30 P.M.	.	Enamel flaked	Enamel flaked	Good	Enamel flaked
1/12/25	5:30 P.M.	1	Enamel flaked	Enamel flaked	Fine crack	Enamel flaked
1/13/25	8:00 A.M.	.	Enamel flaked	Enamel flaked	Several fine cracks	Enamel flaked
1/13/25	8:00 A.M.	1	Enamel flaked	Enamel flaked	Cracks enlarged	Enamel flaked
1/13/25	5:30 P.M.	.	Enamel flaked	Enamel flaked	Additional cracks	Enamel flaked
1/13/25	5:30 P.M.	1	Enamel flaked	Enamel flaked	Additional cracks	Enamel flaked
1/14/25	8:00 A.M.	.	Enamel flaked	Enamel flaked	Additional cracks	Enamel flaked
1/14/25	8:00 A.M.	1	Enamel flaked	Enamel flaked	Enamel flaked	Enamel flaked

Colored ink, rubbed lightly into the enamel surface, brings out very definitely the first indications of crazing which are not readily apparent.

Results of Tests

Typical results obtained with this apparatus are shown in Table I. Four white enamels in which the only changes are in the feldspar and quartz content, as shown, have been applied to ground coated plates and subjected to test. It will be noted that the initial failure occurred in the bending of the plates with readings of from 4 to 9 notches on the machine equivalent to a spring in the plates of from $^3/_{16}$ to $^7/_{16}$ inch. This undoubtedly gives a satisfactory range for the differentiation of the enamels, although the results given in this form are not nearly as expressive of the value of the test as that shown in Table I, or even better than this, actual observations of the enamel during the life of the test.

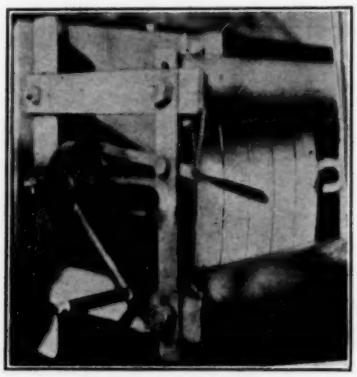

FIG. 3.—View of apparatus showing arrangement of test plates.

These data have been checked with very satisfactory consistency in the results, and it is quite evident that the machine is sufficiently sensitive to measure cross-breaking strength with the required differentiation for all practical purposes. Sufficient data are not available at this time from which to draw general conclusions as to the effect of replacements of feldspar by quartz and the results are offered merely as indicative of what may be expected in the use of the apparatus. It is only necessary to state that the apparatus has been used successfully for several months to permit of the collection of accurate information on the cross-bending strength of enamels produced under factory conditions.

Summary

Impact tests which are valuable in indicating the resistance of enamel kitchen ware and similar articles to ordinary abuse encountered in that type of ware, are not satisfactory for determining the ability of enamel flat ware to withstand stresses set up in its handling and use. The apparatus and the method described above apparently serve very well for the latter purpose, and offer a means for quantitatively determining this property.

A. J. LINDEMANN AND HOVERSON STOVE COMPANY
MILWAUKEE, WIS.

THE THERMAL EXPANSION OF REFRACTORIES[1]

By F. H. Norton[2]

ABSTRACT

The thermal expansion or contraction of a number of typical refractories has been measured up to 1700°C in a neutral or slightly oxidizing atmosphere. In nearly every case the expansion curve has been carried to a higher temperature than given by previous data. In a few cases the expansion curve has been obtained for materials that have not been studied in this way before. It is believed that the expansion curve of a brick, if carried to the softening point, gives valuable information as to the performance of that brick in service.

The thermal expansion of refractories has been studied to a considerable extent up to 1000°C, but above this temperature the observations are few and conflicting. As much valuable information can be obtained from the complete expansion curve of a refractory brick, tests were made on a number of typical refractories up to temperatures of 1700°C.

The information that may be obtained from these expansion curves is summarized as follows:

1. The tendency of a brick to spall, other things being equal, is proportional to the coefficient of linear expansion.[3] The coefficient in most cases varies with the temperature so it is necessary to pick out the temperature at which spalling occurs. This has been found by observation to lie between about 300°C where the thermal strains begin to become serious and 700°C where plastic flow[4] is believed to commence in most materials. Usually the maximum coefficient for the whole temperature range lies between these limits, which alone would account for spalling at these temperatures. The non-spalling possibilities of a given material can therefore be judged by the maximum coefficient of expansion between these two temperatures.

2. Nearly all refractories are composed largely of crystals, which may have two or more allotropic forms each of which is stable over a certain temperature range. The inversion of a crystal to another form is usually accompanied by a change in volume which is sharply indicated on the expansion curve. Thus the expansion curve indicates the form and the relative amount of the crystal components. Also in studying new materials the discontinuities in the expansion curve are an aid in studying that material.

3. The total amount of reversible expansion determines the size of the

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[1] Recd. Aug. 10, 1925.

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[3] F. H. Norton, "A General Theory of Spalling," *Jour. Amer. Ceram. Soc.*, **8** [1], 29–39 (1925).

[4] M. C. Booze and S. M. Phelps, "A Study of the Factors Involved in the Spalling of Fire Clay Refractories," *Jour. Amer. Ceram. Soc.*, **8** [6], 361–82 (1925).

expansion joints needed in wall construction. In the construction of crowns a material with a low coefficient of expansion is desirable to prevent pinching the ends of the blocks.

4. The temperature at which irreversible contraction starts is of considerable importance as this temperature is very close to the maximum temperature at which the refractory may be safely used.

Description of Apparatus

A number of preliminary tests indicated that the expansion and contraction of refractory materials was not the same in the reducing atmosphere of the electric furnace and in a neutral or slightly oxidizing atmosphere. It was therefore decided to make these tests in a gas fired furnace with a neutral atmosphere.

The change in length of a specimen was measured by sighting on the ends with filar telescopes. This gave the length of the specimen directly, without the use of some auxiliary member to bring the measuring point outside of the furnace. In all cases specimens one inch square and nine inches long were used. In most cases they were cut out of a standard sized brick, but where the amount of material was limited, as in the case of zircon, the specimen was molded directly to this size. The ends of the specimen were accurately ground before placing in the furnace.

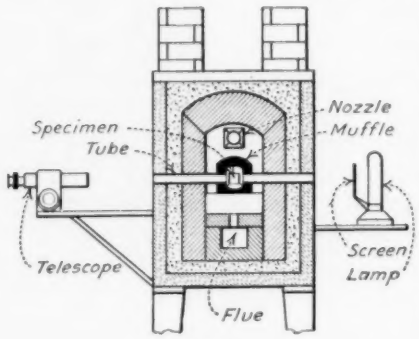

FIG. 1.

A cross-section of the furnace is shown in Fig. 1 and a photograph in Fig. 2. The gas and air from a Maxon premix blower enters under the crown and passes down around the muffle and out through the bottom flue. The muffle was molded in one piece of silicon carbide and four sight tubes were cemented tightly into it. Access to the muffle was gained through the open end.

The telescopes were sighted on the ends of the specimen through the sight tubes and against a bright background produced by lamps with concentrated filaments. This background had an apparent temperature of about 1900°C.

In all runs the temperature was increased at the rate of 100°C per hour. This rate was chosen so that the inside of the specimen would never lag more than 10°C behind the outside. The temperature was measured at low temperature by a calibrated chromel-alumel couple with the tip against the specimen. At 900°C the couple was removed and the temperature

read with an optical pyrometer through the sight tubes. The temperature difference between the two ends of the specimens was never more than 10°C and at the higher temperatures was much less.

The highest temperature used in these tests was 1700°C because the specimens either softened or started to react with the muffle and caused fumes. It is believed, from comparison with other furnaces of the same type, that 1850°C could have been reached.

Precision

The thermocouple was calibrated at the boiling point of water, naphthalene and sulphur and at the freezing point of aluminum and copper. The optical pyrometer was calibrated against a Pt, Pt-Rd couple which had been calibrated at the freezing point of aluminum and copper. At the higher temperatures the pyrometer was checked against a standard instrument at the Massachusetts Institute of Technology. It is believed that up to 1350°C the temperatures are correct to ±5°C and above this to ±10°C.

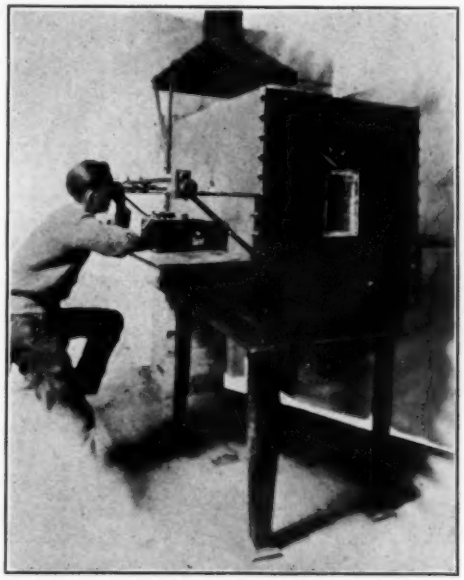

FIG. 2.

When taking a reading of the length of the specimen the cross hairs on the telescope were set several times and the average taken. Except in a few cases at high temperature where the fluxes in the brick bubbled out of the surface the readings are precise to ±.01% of the length of the specimen. The magnesite and lime specimens reacted considerably at temperatures above 1600°, so the readings above that temperature are erratic.

Description of Tests

The following list of refractories was selected for test:

1. Silica brick (Pa.)
2. Kaolin brick (fired at 1300°C)
3. Kaolin brick (fired at 1430°C)
4. Kaolin brick (fired at 1500°C)
5. Kaolin brick (fired at 1620°C)
6. Fire clay brick (commercial brick, Mo.)
7. Fire clay brick (commercial brick, Pa.)
8. Fire clay brick (commercial brick, Colo.)

9. Fire clay brick (commercial brick, Md.)
10. Silicon carbide brick (commercial brick)
11. Zircon brick (pure Fla.)
12. Zircon (brown Fla.)
13. Zirconia brick (Brazilian ore)
14. Mullite brick
15. Magnesite brick (pure Grecian)
16. Magnesite brick (commercial brick)
17. Chrome brick (commercial brick)
18. Spinel brick (magnesia spinel)
19. Lime brick (pure commercial lime crystallized)
20. Alumina brick (fused alumina)
21. Insulating brick (commercial brick)

In every case as full a description as possible has been given of the composition and manufacture of the brick or specimen used. It should be noted that in all cases the materials are of commercial purity such as would be used to make brick, and no attempt has been made in the present investigation to study chemically pure refractory substances.

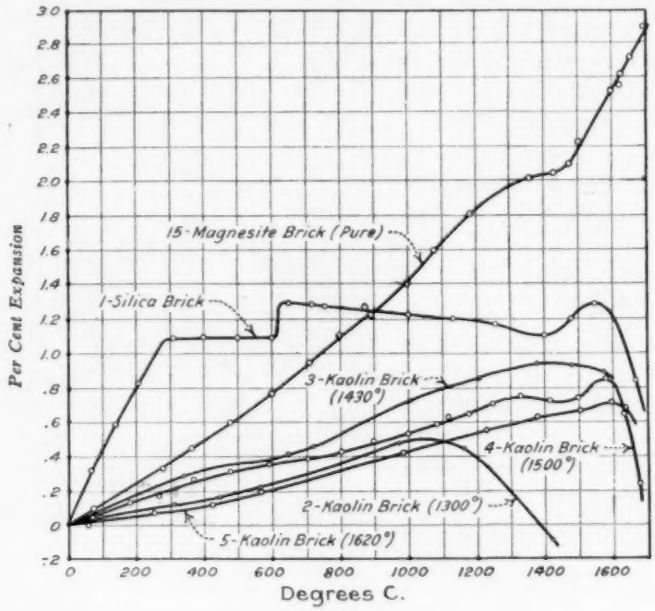

FIG. 3.

The expansion curves for the specimens tested are shown in Figs. 3 to 6. The temperatures in all cases are given in centigrade degrees. The curves are plotted as percentage elongation.

1. Silica Brick (Commercial) The specimen was cut from a standard brick. An analysis of this particular brick was not obtained, but the silica content was probably between 96% and 97%, and according to J. Spotts McDowell[1] contains,

[1] "A Study of Silica Refractories" Amer. Inst. Min. Eng., *Bull.*, Nov., 1916.

Cristobalite	70%	Tridymite	5%
Quartz	25		

In the same reference are shown expansion curves of quartz, cristobalite and tridymite obtained from various sources.

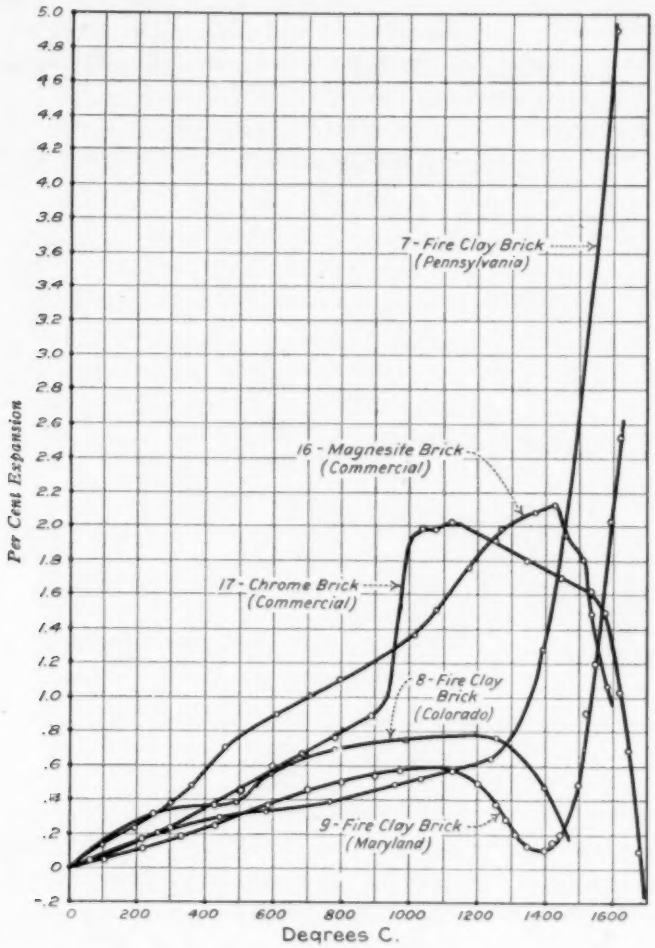

FIG. 4.

The expansion curve for this brick starts up rapidly to 260° where the expansion is 1.09%. The specimen holds this length up to 620° where it suddenly increases to 1.29%. There is no indication of the tridymite inversion point at 110° because of the small amount of this material. The inversion of α to β cristobalite, which is clearly marked at 260°, shows

that there is a large porportion of this material in the brick. The quartz inversion point is sharply defined at 610° showing also a considerable amount of this material in the brick.

Beyond 700° the brick contracts slowly to 1400° and then expands rather rapidly to a maximum at 1525°. Above this temperature the brick shrinks quite rapidly and at 1700° starts to soften. The expansion of the brick above 1400° is due to the conversion of tridymite and quartz to cristobalite as the latter material has the lower average density. Fenner gives the formation temperature of cristobalite as 1470°.

It is believed that a high temperature expansion curve of a silica brick will give more information concerning its quality than any other single test.

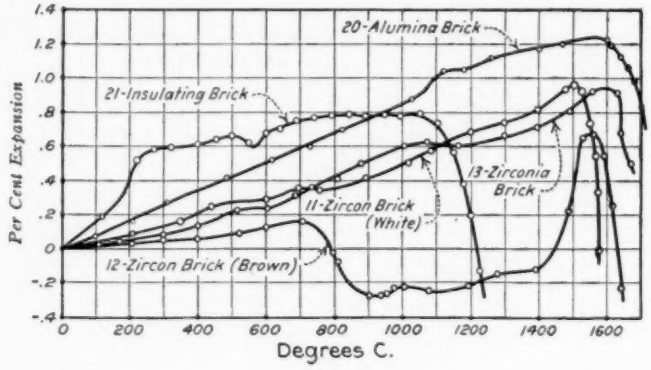

FIG. 5.

2. Kaolin Brick This brick was made of pure kaolin with the following analysis:

Al_2O_3	45.92%	TiO_2	0.35%
SiO_2	52.02	CaO and MgO	none
Fe_2O_3	1.51	Alkalis	trace

The melting point is 1740° (reducing atmosphere).

The grog was fired at approximately 1620° for 30 hours and the brick was fired at 1300°. The structure was soft and crumbly, showing little vitrification of the bond. The porosity was 29.6%.

The specimen shows a steady rate of expansion up to 300°, then it becomes less for the next 200°, and beyond 600° rises more rapidly. The change in slope at 300° corresponds to the inversion of α to β cristobalite, while the increase in slope at 600° corresponds to the inversion of α to β quartz. This portion of the curve indicates the presence of some free silica in the brick in the form of cristobalite and quartz.

The expansion reaches a maximum of .53% at 1075° and then falls steadily as the temperature is increased. This contraction is not reversible

and will continue up to the softening point where it amounts to about -6.8%. It is clear that this brick when fired at such a temperature will show excessive shrinkage in use.

3. Kaolin Brick This brick was the same as Specimen 1 except that it was fired at 1430° for 30 hours. The bond had started to vitrify, giving a fairly strong structure. The porosity had decreased to 26.0%.

The expansion curve rises rapidly to 300°, slowly to 600° and then more rapidly to the maximum at 1400°. The free silica in the bond has not combined at this temperature as the transformation points are even more clearly shown than in the lower fired specimen.

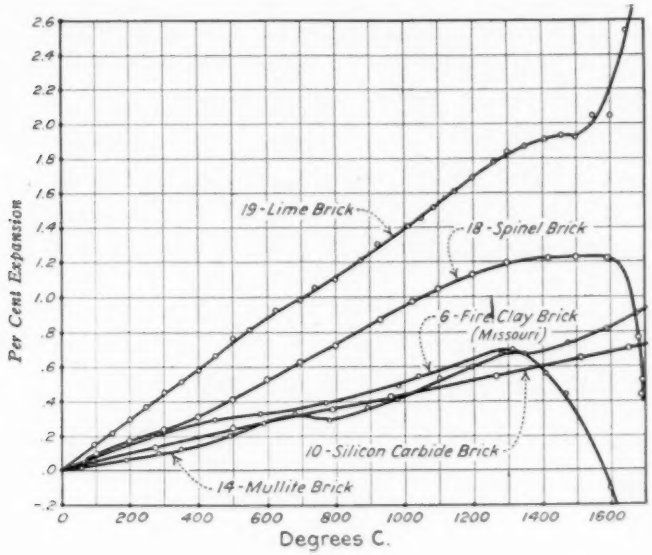

FIG. 6.

The fact that expansion is increased by a higher firing indicates that the bond was vitrified in the second case giving a dense and less porous structure.

The specimen showed a permanent shrinkage above 1400° which increased rapidly above 1600° and amounted to about -6.5% at the softening point.

4. Kaolin Brick This brick was the same as Specimen 1 except that it was fired at 1500° for 30 hours. The brick was harder and more vitrified than the previous specimen, giving a porosity of 24.5%.

The expansion curve rises less rapidly than for Specimen 2 and shows less indication of the silica points. This would indicate that the silica had started to combine with the alumina in the bond to form mullite and silica glass.

The expansion continues up to 1350°, drops off slightly to 1500° and then rises to a maximum at 1570°. This peculiarity in the curve is repeated in the curve for silica brick and must be due to the formation of cristobalite.

The permanent shrinkage is very rapid beyond 1600°C, falling to −6.2% at the softening point.

5. Kaolin Brick This brick was the same as Specimen 1 except that the firing temperature was 1620° for 30 hours. The specimen was very hard and vitrified with a porosity of 18.0%.

The expansion curve is nearly a straight line with a rather low slope. There is only a very slight trace of the silica points, showing that practically all free silica is converted to either glass or mullite.

The greatest expansion is obtained at 1600°, above which a rapid permanent contraction takes place amounting to −5.2%.

This brick can be used up to 1600° with no permanent change in size, but if the brick is used above 1650° (3000°F) some permanent shrinkage will occur. The performance of the brick in service checks up exactly with these figures.

The tests on this brick at different firing temperatures bring out the fact that the silica content of a fire clay brick is not a measure of the coefficient of expansion as has been sometimes believed, for the firing conditions and form of the silica have a considerable influence.

The curves obtained here are in good agreement with the results obtained at lower temperatures by Houldsworth and Cobb[1] on kaolins fired at different temperatures.

6. Fire Clay Brick (Commercial Missouri) This is a brick made from a refractory Missouri clay. An analysis of this brand of brick is given as:

SiO_2	53.12%	CaO	0.64%
Al_2O_3	43.30	MgO	0.46
Fe_2O_3	2.48	Alkalis	0.15

The melting point was found to be 1720° (reducing atmosphere).

This specimen expanded fairly steadily up to 1300°, but showed a slight flattening of the curve between 300° and 600° which indicates a small amount of free silica. Above 1320°, which is probably the firing temperature of the brick, shrinkage occurs with increasing rapidity up to the softening point.

[1] Houldsworth and Cobb, "The Reversible Thermal Expansion of Refractory Materials," *Jour. Amer. Ceram. Soc.*, **6** [5], 645 (1923).

7. Fire Clay Brick (Commercial Pennsylvania) This is a commercial brick made of Pennsylvania flint and plastic clays. The melting point is 1680° (reducing atmosphere) and the analysis is:

SiO_2	54.16%	TiO_2	2.72%
Fe_2O_3	2.70	CaO	0.10
Al_2O_3	38.84	MgO	1.14
		Sulphates	0.20

The specimen expanded quite evenly up to 1200° with little trace of free silica. Above this temperature the specimen exhibited a peculiarity that is inherent in Pennsylvania clays and in few others. This is the so-called secondary expansion which starts in where most clay brick shrink, and increases rapidly up to 5 or 6% at the softening point.

The theory of this expansion has been discussed but as yet no really satisfactory explanation has been advanced. Two facts, however, are significant: the clay does not show this expansion under load, and a fracture of the expanded material shows a series of bubble-like pores. This leads one to believe that at 1200° some of the fluxes soften and in reacting give off a gas, possibly SO_2 or H_2S, which forms bubbles and increasingly bloats the clay as the temperature goes higher.

At first it might be thought that this property would be a distinct disadvantage in use but when the brick are set in a wall the restraint is sufficient to prevent much of this secondary expansion. A test wall made up of brick of this type of clay not only shows no expansion in length or height when heated to 1600° on the surface for 24 hours, but actually shows a slight shrinkage like other clay brick.

8. Fire Clay Brick (Commercial Colorado) This is a brick made from a high silica Colorado clay having the following analysis:

SiO_2	62.55%	TiO_2	0.62%
Fe_2O_3	1.13	CaO	0.20
Al_2O_3	35.40	MgO	0.10
		Alkalis	none

The melting point was 1700° (reducing atmosphere).

This specimen expanded very rapidly at first and showed the silica inversion points very strongly, indicating a considerable amount of free silica. A rapid shrinkage took place above 1250°.

9. Fire Clay Brick (Commercial Maryland) This brick is made from a Maryland flint clay bonded with a similar plastic clay. The analysis of the brick given by the makers is:

Silica	62.32%	Magnesia	0.54%
Alumina	31.65	Alkalis	1.12
Lime	0.10	Titanium oxide	2.30

The melting point is 1610° (reducing atmosphere).

This brick expands up to 1100° rather steadily then starts to shrink rapidly to 1400°. At this temperature the specimen stops shrinking and shows great secondary expansion. This characteristic is rather peculiar, but is due to the same causes as attributed to the Pennsylvania brick. In this case the original firing was so low that actual shrinkage took place before the secondary expansion started.

10. Silicon Carbide Brick (Commercial) This brick is made of pure SiC crystals fritted together at high temperature. No clay bond was used.

The specimen expanded rather rapidly up to 300° after which the slope decreased slightly and remained the same up to the highest temperatures reached. The presence of a very small amount of silica is indicated. On the whole the coefficient of expansion is about the same as kaolin or bauxite and not much lower, as has been sometimes stated.

11. Florida Zircon (ZrO_2-SiO_2, White) This specimen was made from a purified beach sand. It was white in color and was composed of evenly sized particles.

The analysis is as follows:

SiO_2	30.80%	ZrO_2	66.43%
Al_2O_3	1.78	Sulphates	trace
TiO_2	0.50	Undetermined	0.37

It is impossible at present to tell what is the proportion of zircon and zirconia, although the former is supposed to predominate.

The melting point was above 2000° (reducing atmosphere).

The sand was mixed with molasses and fired for two hours at 1650° which gave a firm structure with little vitrification.

The specimen expanded rather slowly to a maximum at 1500° and then shrank rapidly. An inversion point is indicated at 800°, and a slight inflection at 260° and 600°. The latter points indicate some free silica.

12. Florida Zircon (ZrO_2-SiO_2, Brown) This specimen was made from a less purified zircon sand from the same source as the preceding sample. It had the following analysis:

SiO_2	25.00%	TiO_2	9.02%
Al_2O_3	10.50	ZrO_2	55.77

The melting point was 1935° (reducing atmosphere).

The sand was mixed with molasses and molded. It was fired at 1590° for 4 hours.

This specimen showed a low and even expansion at the lower temperatures, but at 800° contracted reversibly nearly one-half a per cent. At 1400° it expanded rapidly to 1550° where it began to shrink.

13. Brazilian Zirconia (ZrO_2)

This brick was made of zirconia ore from Brazil having the following analysis:

Fe_2O_3	1.60%	SiO_2	27.26%
Al_2O_3	7.75	ZrO_2	60.44
CaO	0.04	Undetermined	2.91

The melting point was over 2000° (reducing atmosphere).

The lumps of ore were fired for 4 hours at 1700° which changed their size or appearance very little. The lumps were crushed with difficulty to pass a 4-mesh screen. This was bonded with 20% fine crushed raw ore and 20% molasses solution. The dried brick were fired for 8 hours at 1675° and showed a linear shrinkage of only 2.3% but were slightly distorted. A section of the brick showed that it was well vitrified with a number of bubble-like pores.

The specimen started to expand at a low rate up to 300° and then more rapidly up to 500°. From 500° to 600° it was nearly constant but above this it rose rapidly to 1075° where there was a dip in the curve. This would indicate the presence of some free quartz and some change in the crystal structure at 1100°. Of the silica shown in the analysis, some is free, some combined with the alumina and probably some is in the form of zircon.

The maximum expansion is reached at 1600° above which there is a rapid shrinkage. The expansion curve is very similar to that for the white zircon.

14. Mullite Brick

Biscuits were made up of kaolin and bauxite in such proportions as to make a composition of 72% Al_2O_3 and 28% SiO_2, according to the diagram of Bowen and Greig. The biscuits were fired for 10 hours at 1780° and were converted almost completely to very fine close grained mullite crystals.

The biscuits were crushed to pass a 4-mesh screen, bonded with 30% raw material of the same composition as the biscuit and fired for 4 hours at 1785°. The brick were very hard and vitreous but with numerous pores.

The specimen expanded rather slowly to 700°, contracted slightly up to 800° then expanded steadily up to 1300°. Between 1300° and 1400° the expansion was quite low but increased again up to 1700° where the specimen started to react rather violently with the muffle.

Two inversion points occur, a very distinct one between 700° and 800° and a less definite one between 1300° and 1400°. The first one is probably due to a change of form in the mullite crystals. The second one corresponds with the dip in the silica curve at the same temperature and indicates a slight excess of silica in the brick.

15. Magnesite Brick

This brick was made of pure Grecian magnesite with approximately the following analysis:

SiO_2	3.0%	MgO	89.0%
CaO	2.5	Ignition loss	5.0
Fe_2O_3 and Al_2O_3	0.5		

The melting point was over 2000°.

The calcined material was made into biscuits and fired for 10 hours at 1780° which converted it almost completely into periclase crystals. A very few forsterite crystals were observed.

The biscuits were crushed up to pass a 4-mesh screen and bonded together with 16% of raw magnesite. The brick were then fired at 1680° for 4 hours. They were strong but rather porous and were of a light straw color.

The specimen expanded rapidly and steadily up to 1000° where there was a slight increase in slope. At 1400° there was a small dip in the curve that undoubtedly corresponds to the inversion of the small amount of α periclase in the original brick to β periclase. Above this point the length increased rapidly to a little over 1700° when the fumes caused by the reaction of the specimen and muffle made it impossible to take further readings. The expansion is reversible.

Magnesite is remarkable in having a large and regular expansion which makes the brick rather sensitive to temperature changes and makes large expansion joints necessary.

16. Magnesite Brick (Commercial) This is a commercial magnesite brick which probably contains some iron oxide to bring down the vitrifying point. The brick was dark brown in color and was quite dense.

The expansion curve started up in the same way as the preceding specimen, but at 400° showed an increase in slope due probably to magnesia-iron compounds. This hump in the curve is confirmed by the tests of R. H. H. Pierce[1] on a similar brick. The increase in slope at 1000° is identical with that on the previous specimen. The expansion then continues up to 1440° where it starts to shrink irreversibly to 1680°, after which it shrinks very rapidly beyond the range of the telescopes. This shrinkage is probably due to the change of α to β periclase, which had not been completed in the initial firing.

17. Chrome Brick (Commercial) This is a commercial chrome brick, probably running rather high in iron, but with a high melting point.

This material expands rapidly, with a trace of an inversion point at 600° which indicates a little free quartz. At 1000° there is a tremendous change in size, indicating that some inversion has occurred. This change comes at such a high temperature, however, that it should not cause spalling.

[1] J. S. McDowell and R. M. Howe, "Magnesite Refractories," *Jour. Amer. Ceram. Soc.*, **3** [3], 227 (1920).

Above 1150° a slow contraction takes place and at 1500° rapid shrinkage starts in.

18. Spinel Brick This brick was made up as follows: Grecian magnesite was ground intimately with a pure bauxite in the correct proportions to give magnesia spinel. This material was made into biscuits and fired for ten hours at 1730°. The product consisted of about 90% spinel crystals, the remainder being mainly silica and titanium oxide. The biscuits were crushed into grog and bonded with raw bauxite and magnesite in the original proportions. The brick were then fired for four hours at 1690°.

The brick were light colored, composed of many fine crystals and very hard. The melting point was over 2000° (reducing atmosphere).

The specimen expanded fairly uniformly up to 1400°, remained constant to 1600°, then shrank rapidly. There were no indications of inversion points.

19. Lime Brick Pure, calcined lime was heated for four hours at a temperature between 1850° and 1900° in a gas furnace. After cooling, the lumps were hard and composed of glistening crystals. They showed little tendency to slake after one month's exposure in the air.

The lumps were crushed into grog and pressed into specimens without bond. They were fired for one hour at 1740° and gave a firm, hard structure.

The specimen expanded evenly and rapidly to 1500° where an inversion point occurs. Above this temperature the expansion continues rapidly. As this curve is very similar to the magnesite curve it is probable that there is an α and β form of crystallized calcium oxide with an inversion temperature at 1500°.

20. Fused Alumina The fused alumina was in crystals of about 28 mesh size. The analysis showed the material to be quite pure:

Al_2O_3	95.50%	Fe_2O_3	0.44%
TiO_2	3.94	MnO	0.10

The melting point was about 2000°.

The specimen was made without bond and fired at 1650°.

The specimen expanded very evenly up to 1050°, then it expanded rapidly to 1110° and remained nearly stationary up to 1180°. Above this the expansion was regular to 1.23% at 1600°, where irreversible contraction started and reached .70%. Had the specimen been fired harder this contraction would not have taken place.

An inversion point is indicated between 1100° and 1200°.

21. Insulating Brick

This is a commercial insulating brick composed mainly of infusorial earth, and has therefore a very low apparent density. The composition is mainly silica. The melting point is 1630° (reducing atmosphere).

The expansion was rapid up to 250° and then very slight up to the shrinkage point at 1050°. A slight dip is evident at 600°, indicating some free quartz.

Discussion of Results

The important characteristics of the specimens tested are assembled in Table I below:

TABLE I

Specimen no.	Type of brick	Melting point (reducing atmos.)	Firing temperature	Mean coeff. $\times 10^{-7}$ of expansion between 0°C and shrinking temperature	Max. coeff. $\times 10^{-7}$ of expansion between 300°C and 700°C	Max. irreversible contraction or expansion up to 1700°C	Inversion points	Changes in slope	Temperature at which shrinkage or expansion begins
1	Silica	1700°	..	83	1000	1%	260°, 610°	1400°	1550°
2	Kaolin	1740	1300°	47·	79	1	260°, 600°	..	1050
3	Kaolin	1740	1430	68	87	1	260°, 600°	..	1380
4	Kaolin	1740	1500	53	70	1	260°, 600°	..	1580
5	Kaolin	1740	1620	43	67	1	....	..	1610
6	Fire Clay (Mo.)	1720	..	54	80	Large	600°	..	1300
7	Fire Clay (Pa.)	1680	..	51	64	—5	600°	1250	1250
8	Fire Clay (Colo.)	1700	..	54	174	Large	260°, 600°	..	1220
9	Fire Clay (Md.)	1610	..	45	80	—3	....	..	1100
10	Silicon Carbide	2000+	..	43	48	0	....	..	1700+
11	Zircon (white)	2000+	1650	64	92	Large	800°	1400	1510
12	Zircon (brown)	1935	1590	42	48	2	600°, 1400°	..	1550
13	Zirconia	2000+	1675	59	87	1	800°, 1150°	..	1600
14	Mullite	1850	1785	53	82	0	780°, 1350°	..	1700+
15	Magnesite (pure)	2000+	1680	142	151	0	1430°	1000	1700+
16	Magnesite (commercial)	....	..	147	210	2	....	500	1440
17	Chrome (commercial)	....	..	104	124	2	1000°	1130	1540
18	Spinel	2000+	1690	76	110	1	....	1200	1600
19	Lime	2000+	1740	138	145	0	1500°	700	1700+
20	Alumina	2000+	1650	77	82	1	1180°	..	1580
21	Insulating	1630	..	74	480	Large	200°, 570°	..	1050

If the specimens are listed in the order of their melting point as in Table II, we obtain an idea of their value for high temperature use.

The first seven specimens may be classed together as very refractory materials for the highest temperature use. The mullite and kaolin belong to an intermediate class, while the silica and fire clay are at the bottom.

TABLE II

Specimen No.	Material	Melting point
15	Magnesite (Grecian)	2000° (pure 2800°)
19	Lime	2000° (pure 2570°)
13	Zirconia	2000° (pure 2550°)
11	Zircon (white)	2000°
18	Spinel	2000°
20	Alumina	2000° (pure 2035°)
10	Silicon Carbide	2000° (decomposes at 2200°)
12	Zircon (brown)	1935°
14	Mullite	1850°
5	Kaolin	1740°
1	Silica	1700°
6, 7, 8, 9	Fire Clay (av.)	1670°
21	Insulating Brick	1630°

It should be emphasized that a high melting point does not necessarily give a high duty refractory, but a high melting point is a primary essential, before other properties can be considered.

In general, the material for a refractory structure should have as small a mean coefficient of expansion as possible. In Table III the various specimens are listed in the order of excellence.

TABLE III

Specimen No.	Material	Mean coefficient of expansion
12	Zircon (brown)	0.0000042
5	Kaolin (hard)	.0000043
10	Silicon Carbide	.0000043
6, 7, 8, 9	Fire Clay (av.)	.0000051
14	Mullite	.0000053
13	Zirconia	.0000059
11	Zircon (white)	.0000064
21	Insulating Brick	.0000074
18	Spinel	.0000076
20	Alumina	.0000077
1	Silica	.0000083
17	Chrome	.0000114
19	Lime	.0000138
15	Magnesite (Grecian)	.0000142
16	Magnesite (commercial)	.0000147

The brown zircon, kaolin and silicon carbide have the lowest coefficients. The fire clay, mullite and zirconia are a little higher, while the spinel, alumina and silica form a still higher group. The chrome, lime and magnesite have values distinctly above the others. Structures made from the last three materials will require carefully designed expansion joints.

As previously stated the ability of a material to resist spalling depends, other things being equal, on the maximum coefficient of expansion between 300° and 700°. In most cases this will be the maximum for the complete temperature range. The different materials are listed below in Table IV to bring out their spalling resistance.

TABLE IV

Specimen No.	Material	Maximum coefficient of expansion between 300° and 700°
12	Zircon (brown)	0.0000048
10	Silicon Carbide	.0000048
5	Kaolin (hard)	.0000067
14	Mullite	.0000082
20	Alumina	.0000082
13	Zirconia	.0000087
11	Zircon (white)	.0000092
6, 7, 8, 9	Fire Clay (av.)	.0000099
18	Spinel	.0000110
17	Chrome	.0000124
19	Lime	.0000145
15	Magnesite (Grecian)	.0000151
16	Magnesite (commercial)	.0000210
21	Insulating Brick	.0000480
1	Silica	.0001000

The materials most resistant to spalling are zircon, silicon carbide and kaolin. Mullite, alumina, zirconia, fire clay and spinel are somewhat less resistant and chrome, lime and magnesite will spall rather easily.

TABLE V

Specimen No.	Material	Temperature at which shrinkage begins
10	Silicon Carbide	1700°+
14	Mullite	1700+
15	Magnesite (Grecian)	1700+
19	Lime	1700+
5	Kaolin (hard)	1610
18	Spinel	1600
13	Zirconia	1600
20	Alumina	1580
1	Silica	1550
12	Zircon (brown)	1550
17	Chrome	1540
11	Zircon (white)	1510
16	Magnesite (commercial)	1440
6, 7, 8, 9	Fire Clay Brick (av.)	1220
21	Insulating Brick	1050

Silica is in a class by itself in regard to spalling. In general this classification agrees well with the behavior of these materials in service.

The temperature at which a material begins to shrink is a good indication of the maximum temperature that it will stand in service. This temperature not only depends on the material but also on its structure and firing temperature, so the values given in Table V do not indicate the possibilities of all the materials.

Silicon carbide, mullite, magnesite and lime show no shrinkage up to 1700° and may therefore be classed as very high duty refractories. Kaolin, spinel, zirconia and alumina shrink around 1600°, while silica, chrome and zircon are somewhat lower. Fire clay brick start to shrink at about 1220°.

Acknowledgments

Acknowledgment is made of the assistance of Robert Richardson, R. E. Swift and G. F. Boyd, all of the laboratory force of the Babcock and Wilcox Company, in carrying out much of the experimental work.

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METAL POROSIMETER FOR DETERMINING THE PORE VOLUME OF HIGHLY VITRIFIED WARE[1]

By Louis Navias

ABSTRACT

A metal porosimeter of the McLeod-Gage type has been developed for use in determining the porosity of highly vitrified ware. The glass capillary is welded directly on to the 20% chrome-steel metal cap. The metal construction gives a rugged apparatus that can be safely handled for routine work. It is as sensitive as the similar glass apparatus of Washburn and Bunting, but is not structurally delicate. A photograph and drawing with details are included. The suggestion is made that the results obtained by these types of apparatus be expressed as "per cent pore volume," and that the results obtained by water soaking be specifically named "per cent water absorption" to distinguish between them. Results are given to show that for fairly vitrified ware, the water boiling method gives much lower porosity than the method using air as the fluid.

In their study of porosity, Washburn and Bunting[2] developed several types of glass apparatus for the determination of porosity using air or a gas as the fluid medium, in contradistinction to the absorption methods where water, kerosene and vaseline are utilized. For highly vitrified bodies, that is for ware having low porosities, the McLeod-Gage type of porosimeter was recommended.

Such a glass apparatus has been in use in the writer's laboratory for the past year and it has been found to give satisfactory results. There are, however, certain structural weaknesses due to the fact that the apparatus is made of glass. With use the ground glass joint becomes worn, resulting in the cap being sometimes lifted by the mercury, even though it is held in place by extended rubber bands. Care must be taken to prevent sharp impact of the specimen against the glass sides. The specimen has a tendency to remain in close contact with the side of the receptacle when raised by the mercury, and is often retained by the protruding rim of the ground glass joint of the upper half of the apparatus. Sometimes the specimen is dislodged and rises with great force against the glass top, and is liable to do great damage. On account of these facts it was found inadvisable to advocate the use of this precision apparatus by those not particularly familiar with laboratory technique.

Metal Porosimeter

The above-mentioned undesirable features have been eliminated by the construction of a practically all-metal porosimeter. The photograph shows both the glass and metal types, the glass apparatus being assembled while the metal apparatus is unassembled, with the threaded steel collar supported by a clamp merely to show its relative position.

[1] Recd. Aug. 15, 1925.

[2] *Jour. Amer. Ceram. Soc.*, **5** [8], 528 (1922).

The metal receptacle and cap were made from solid rods of metal, the lower half or receptacle for the test specimens being made of ordinary steel and the upper half or cap being made of steel containing 20% chromium. The inside surfaces are finished as smooth as possible to minimize the entrapping of air when the mercury flows over the surface. The ground glass joint is replaced by a ground metal-to-metal joint having a taper of 45°. For assembling, the two halves are brought in contact, except for the interception of a thin layer of stop-cock grease between the parts of the joint. The collar is threaded into place and if necessary it may be tightened by a spanner wrench. A good vacuum-tight joint is thus easily obtained.

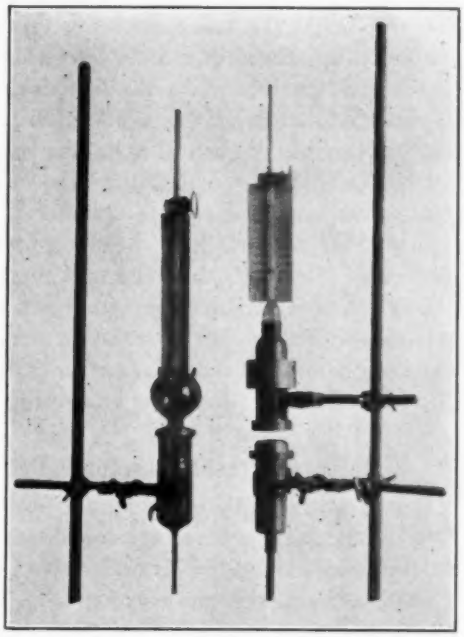

FIG. 1.—Glass and metal porosimeters. McLeod-Gage type.

Soft glass can be welded to a tapered chrome steel part and this is the reason for the choice of the special steel. The glass expansion bulb between the metal cap and glass capillary is necessary to enable observation of the rise of the mercury. No effect of the mercury on the metal parts has been noticeable after some months of use.

It will be noted that the glass apparatus has a spherical expansion chamber with a constriction below it to prevent the test piece from rising into it. In the metal apparatus, the expansion chamber is cylindrical having the same diameter as the receptacle. A metal pin welded into the bottom of the cap, acts as an obstruction to the rising test piece, but not to the mercury or gases. By this means the upper half of the apparatus acts as an expansion chamber.

In both the metal and glass types there are places in the apparatus, especially edges and contacts over which the mercury flows and entraps air. For each apparatus the quantity of entrapped air is a constant. On the photograph it will be seen that the zero mark of the calibrations of the capillary tube begins not at the actual end of the tube at the stop-cock but below it. The difference in height (or volume) is the constant referred to, and is determined only once. The glass apparatus illustrated

had a constant of 0.11 cc., whereas the glass apparatus of Washburn and Bunting had a constant of 0.14 cc. The metal apparatus has a constant of 0.24 cc.,[1] and requires a slightly longer or larger capillary tube for the same working volume. By more careful workmanship in construction the constant could be diminished.

After the space around the specimen has been displaced with mercury and the stop-cock has been closed, the mercury reservoir is lowered until the specimen reaches the bottom of the receptacle and is surrounded by the gases held in its pores. In the glass apparatus the level of the mercury in the tube below the receptacle is ascertained by visual inspection. With the metal apparatus it is only necessary to determine once the level 76 cm. below the bottom of the receptacle, which must be reached by the leveling bulb to insure the same conditions. The lowering of the mercury and specimen in the metal apparatus causes a vibration which is readily felt by the disengaged hand, and the vibration ceases when the specimen reaches the bottom of the receptacle.

A number of tests have been made determining the pore volume of specimens with both the glass and metal apparatus. In most instances the values obtained were similar, but there were a few anomalous cases, in some of which values with the glass apparatus were consistently higher, while in the others, the values with the metal apparatus were the higher. The cause for the differences was unexplainable.

Effect of Freshly Fractured Surfaces of Ware on Results

It is essential in determining the pore space of a material that at least 50% of the surface be newly fractured. This point is clearly shown by the following examples. Porcelain bars 4 inches long, with a cross-section of 1 square inch, were subjected to test.

Specimen	Per cent pore volume	
	1	2
(*a*) One end fractured	0.05	0
(*b*) Both ends fractured	0.06	0
(*c*) Same pieces broken through the middle	0.18	0.30

During the molding, finishing and drying processes, the very fine particles of material are brought to and rubbed over the surface, and in the firing process they form a vitreous skin, often more vitreous than the interior of the specimen.

Method of Determination

For the sake of completeness, the procedure for testing is included here as incorporated in the Test Methods of the Engineering Laboratory.

[1] Since the above article has been written another metal porosimeter has been built having a constant of 0.20 cc.

(*a*) After the (fractured) pieces have been assembled in the receptacle of the test instrument and the cap secured in position, the air surrounding the pieces shall be displaced by the mercury by lifting the mercury-leveling

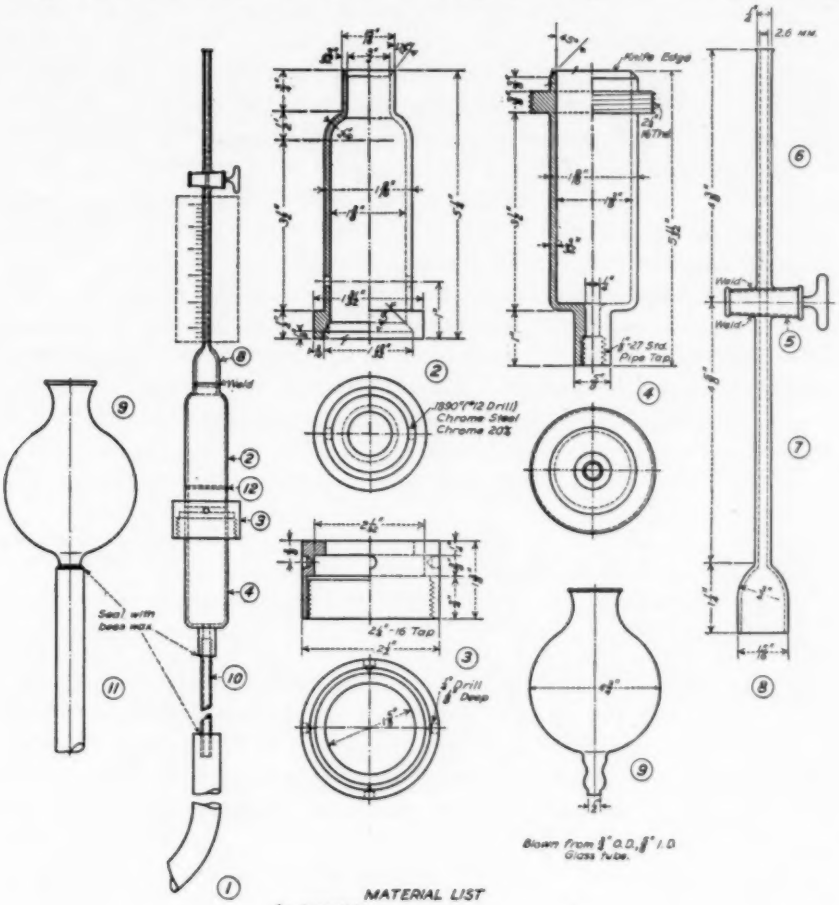
Knife Edge
2.6 MM.
Weld
Weld
Weld
Seal with bees wax
1890"(#12 Drill)
Chrome Steel
Chrome 20%
24"-16 Tap
Drill Deep
Blown From ¼" O.D., ⅛" I.D. Glass Tube.
MATERIAL LIST
1 - Assembly
2 - Cap
3 - Collar (steel)
4 - Receptacle (steel)
5 - Stop Cock 2 MM. hole (glass)
6 - Tube (glass)
7 - Gauge Tube (glass)
8 - Assembly of Stop Cock and Tubes
9 - Mercury Container (glass)
10 - Pipe ⅛", 12" long, one end threaded (seamless steel tube, iron pipe size)
11 - Hose, 1" O.D., ¼" I.D., 5'0" (rubber)
12 - Pin, 1/16" × 2⅛" (steel)

FIG. 2.

bulb. When the mercury level is above the stop-cock, the latter shall be closed. The mercury-leveling bulb shall then be lowered until the lowest surface of the porcelain pieces is entirely exposed. By this means the

gas in the porcelain expands in the outer vacuum, and by a subsequent raising of the leveling bulb the gas is accumulated in the capillary. When the level of the mercury in the leveling bulb and in the capillary are at the same height the gas is at atmospheric pressure, and its volume (V_1) shall be read.

(*b*) The stop-cock shall then be opened and the entire procedure of lowering the mercury level below the specimen, removal of surrounding air, expansion of gas into the surrounding vacuum and accumulation of gas in the capillary, shall be repeated. The second reading of volume (V_2) of gas represents the volume of fine pore space in the specimen. A repetition of the procedure should give a third reading of volume (V_3) similar to the second one. The first value (V_1) is usually too high, since the volume of gas obtained consists of air entrapped on the sides of the porosimeter and held in coarse pockets in the piece of porcelain, and in the fine pores to be measured, and therefore should not be used as a basis for calculation.

(*c*) The total volume (V) of the pieces of each specimen shall be obtained by any suitable volumeter or method, measuring to the nearest 0.2 cc.

(*d*) The pore volume in per cent for each specimen shall be calculated as follows:

$$\text{Per cent pore volume} = \left(\frac{V_2 + V_3}{2}\right)\left(\frac{100}{V}\right)$$

Where V = total volume of test specimen as determined in par. (*c*)

V_2 and V_3 = the second and third volume determinations of gas as determined in par. (*b*).

. . . . . .

During a run, in case of doubt as to whether the joint is vacuum tight the specimen may be repeatedly subjected to the vacuum and the volume of gas obtained measured after each exposure. If the volume of gas remains the same, then no more gas is being expelled, nor is there a leak. An alternative method is to expel the gas accumulated and then to close the stop-cock and subject the specimen to the vacuum. In this case if there are no leaks, nor gas in the pores, the mercury in the capillary will rise to the contact with the stop-cock.

It is hoped that the types of apparatus employing air as the fluid medium will become more popular, and that their use will be encouraged, and it is suggested that the porosity determined by these means be expressed as "per cent pore volume," signifying the per cent of actual pore space by volume. And where the absorption method is used, that the results be fully described as for instance "per cent water absorption," signifying the per cent of weight of water absorbed by the weight of ware. The relation between the two ways of expressing porosity for porcelain (density 2.38) is given by the equation,

$$\text{Per cent water absorption} \times 2.38 = \text{Per cent pore volume.}$$

"Water Absorption" versus "Pore Volume"

The relative merits of the two methods for determining porosity could properly form subject matter for another paper. However, the following table shows actual values obtained by the two methods.

Experimental body no.	Per cent water absorption: 4-Hr. boiling	Per cent water absorption: 100-Hour immersion. 1 hr. boiling each 24 hours	Per cent pore volume calcd. from 100-hour immersion test	Per cent pore volume detd. (1)	Per cent pore volume detd. (2)
190	0.005	0.05	0.12	0.37	0.62
191	.01	.07	.17	.35	.25
192	.005	.07	.17	.66	.52
193	.02	.06	.14	.58	.72
194	.02	.07	.17	.47	.42
195	.01	.06	.14	.46	.20

The identical pieces were used in the 4-hour test as in one of the two determinations for per cent pore volume. It is quite evident that the water absorption method gives much lower results than the method advocated here. There is no doubt that a gas will penetrate into pores which cannot be filled by boiling water in the usual procedure.

RESEARCH LABORATORY
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SCHENECTADY, N. Y.

A LABORATORY LOAD FURNACE[1]

By P. D. Helser[2]

ABSTRACT

This paper illustrates the advantages of the laboratory load furnace. The points emphasized are: (1) direct application of load to specimen; (2) perfect alignment of specimen beneath the load; (3) control of temperature ; (4) control of specimen chamber atmosphere; and (5) measurement of volume changes of the specimen throughout the test.

In research work on refractories, a small type of load furnace is very useful for differentiating between the load carrying properties of the various members of a series of bodies. It would be tedious and expensive from the standpoint of time and labor to make full sized brick specimens. It would also be expensive from the standpoint of raw materials, especially if superrefractories were the subject of investigation.

The laboratory load furnace as shown in Fig. 1 is an Ajax-Northrup high frequency induction furnace. It will accommodate specimens from one square inch in cross-section by 2 inches in length to 4 square inches in cross-section by 4 inches in length. Either the standard time-temperature-weight treatment for load tests as specified by the American Society for Testing Materials may be obtained or higher temperatures may be employed, the limit being the refractoriness of the alundum anvils and the specimen chamber walls.

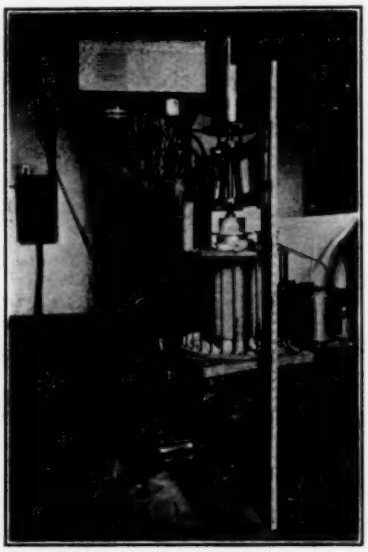

Fig. 1.

The manner of applying the load is rather unique in that the load rides directly on the specimen which in turn is supported on a scale platform, there being no levers or knife edges other than those on the scale itself. After having determined the weight required by carefully measuring the specimen and calculating the total load, sufficient buck shot are added in the hopper to equal this, due allowance being made for the tare weight of the lower anvil and supporting block.

The steel member through which the load is applied is held in a vertical position by means of two adjustable bronze bushings with rounded inner

[1] Published by permission of the Director, U. S. Bureau of Mines, Department of Commerce. Recd. Sept. 14, 1925.

[2] Ceramic Engineer, Ceramic Experiment Station, Bureau of Mines.

edges which make line contacts with the member, thus minimizing friction. A leveling surface is provided on the member.

The volume changes of the specimen may be closely followed by an Ames dial which is attached to the vertical steel member and to the guide frame.

The temperature may either be measured by an optical pyrometer from above, through an axial hole in the upper anvil or through a similar hole in the lower anvil by a thermocouple. Obviously, the thermocouple may be used above, if the optical pyrometer is not used.

Inasmuch as the furnace is a muffle type, either oxidizing, neutral or reducing conditions may be maintained about the specimen by the introduction of a given gas through a water seal at the bottom of the furnace. If desired, the top may also be sealed similarly.

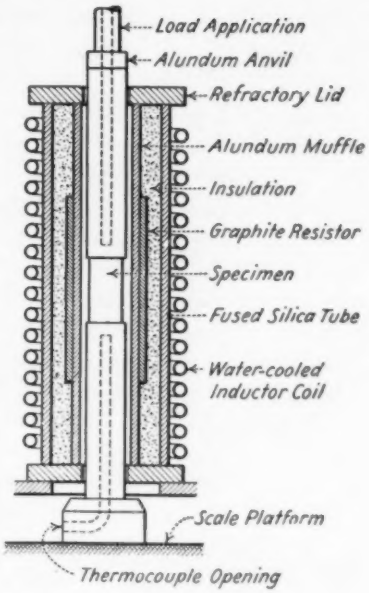

FIG. 2.

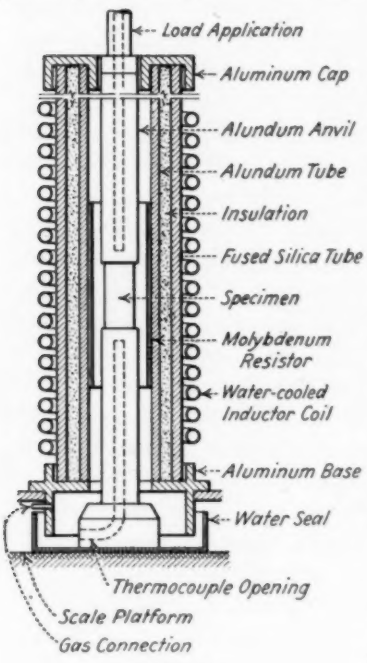

FIG. 3.

A cross-section of the furnace is shown in Fig. 2. The location of the specimen and anvils is clearly shown. The section of graphite resistor is shown immediately without the alundum muffle. A fused silica tube serves as a retaining wall for the insulation which may take the form of calcined magnesia. Lastly the water cooled inductor coils are shown surrounding the furnace proper.

Fig. 3 shows the cross-section of a furnace similar to the above with the exception that the resistor unit is a molybdenum tube instead of graphite. It is located within the specimen chamber in order to favor the alundum tube when the furnace is used for still higher temperatures. It is necessary to maintain either a neutral or reducing atmosphere in the specimen chamber on account

of the tendency of the molybdenum tube to oxidize readily. The gas is introduced through the wall of the water seal shown at the bottom of the furnace.

Different types of furnaces such as a carbon resistance, a resistor bar, a gas fired or an oil fired furnace would lend themselves equally well to this load-application equipment.

In summarizing, the following points are worthy of note:

1. Direct application of load to specimen thus minimizing the error due to friction.
2. Perfect alignment of specimen beneath the load thus minimizing the tendency to fail through shear.
3. Control of temperature.
4. Control of specimen chamber atmosphere.
5. Measurement of volume changes of the specimen throughout the test.

Discussion

S. M. PHELPS: How long does the molybdenum tube last in service? We found in the course of some experimental work that the use of this type of tube does not seem to be good practice. How do you weld this material? Is it not possible that the metal of the couples will be heated above the furnace temperature by the eddy currents of induction? Another point is that you measure the compression of the specimen by observing the movement of the rod which applies the pressure; this measurement includes any linear change of the furnace parts.

P. D. HELSER: With regard to the life of the tube, since the furnace has just been built I cannot say how long the tube will last.

As to the welding of the tube, no effort was made to do this. Instead, it was simply rolled into a cylindrical shape and used without being welded.

With regard to the effect of the eddy currents of induction on the reading of the thermocouple no difference was found in the temperature readings. This matter was also taken up with the Ajax-Northrup people and their reply was confirmed by our findings.

With regard to your statement concerning the volume changes of the furnace parts during the test, obviously there would be a thermal expansion of the refractory anvils. Inasmuch as anvils made from the same material were used in each test, the expansion over a given temperature range was considered constant in each test and the results obtained were comparative. It would be possible to obtain absolute values by first running a blank thermal expansion test on the refractory anvils.

L. J. TROSTEL: Is it proposed to have this small load furnace, which will accommodate small test specimens only, replace the larger type of load furnace which will accommodate standard brick specimens? Were

the specimens used cut out of standard brick or were they made up in some other manner?

P. D. HELSER: It is not proposed to have the small load furnace described replace the larger type of furnace. Instead, the smaller type of load furnace would be especially useful for determining the load carrying properties of a large series of refractory bodies all made up in the same way. Obviously, after the field had been narrowed down to a limited number of bodies which were found to possess good load carrying properties, standard size brick specimens would then be made and tested in the standard larger type of load furnace.

The specimens used were not cut from brick specimens but were made by the dry press process in the size of the specimen tested.

L. J. TROSTEL: I think a good many of us have found from experience that it is frequently erroneous to consider that the test results obtained on small bars and specially molded pieces are typical of what will happen to the regular run of plant product in the commercial shapes and sizes. This, I believe, would be particularly so in the use of such a load testing machine as Mr. Helser has just described which only tests small cylinders.

It does not seem that data comparable with actual service conditions would result and that primarily is what we are really interested in. Mr. Helser's apparatus strikes me as undoubtedly being an admirable testing device for furnishing comparative data on different ideal specimens but it does not furnish the best approximations to actual service loadings, which, I should say, are only to be achieved by using regular plant run refractories intended for the service the load test simulates, with their usual variations in grind, firing, etc. The present A. S. T. M. load test apparently is better suited to give us this type of information at present.

A LABORATORY KILN FOR OBTAINING HIGH TEMPERATURES[1]

By F. H. Norton[2]

ABSTRACT

A small, gas-fired, laboratory kiln is described capable of firing or melting refractory materials up to 1850°C (cone 38). It is pointed out that the flame temperatures reached approach the theoretical values computed from the heat of combustion and the specific heat of the products of combustion.

The high temperature kiln shown in Figs. 1 and 2 consists of a 24-inch cubical chamber with 9-inch walls. The top of this chamber is covered with a crown supported from the top of the walls. All of the brick exposed to the hot gases are special Babcock and Wilcox brick capable of carrying load at very high temperatures. The joints are made as thin as possible and the inner surface is washed over with cement.

The combustion gases enter the kiln through the back wall by means of a carefully tapered tuyere. This tuyere is just below the crown so that the flame passes over the charge and down to the lateral, bottom flues. The gases are collected by the four stacks at the corners of the kiln and pass out at the top. This stack construction prevents heat loss through the corners of the kiln and allows a close equalization of the temperature by partially closing off the stacks.

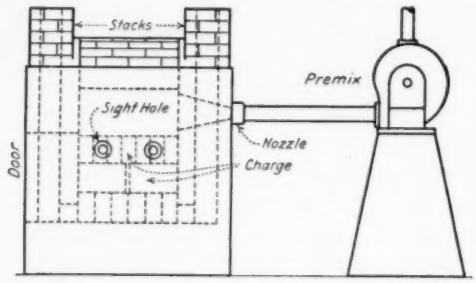

Fig. 1.—Side view of high temperature kiln.

The door is in the front wall and is large enough to give easy access to the interior. The insulation consists of insulating brick $2^1/_2$ inches thick. These are surrounded by a steel shell.

Gas and air are supplied to the kiln by a Maxon Premix blower delivering into a 4-inch pipe. Care was taken to have no bends or restrictions in the line. About 5000 cu. ft. per hour of natural gas are used at the higher temperatures.

The kiln will hold from ten to twenty bricks in a charge, and they are usually set on edge with $^1/_2$-inch spaces between them. The kiln will also hold several large crucibles for making fusions. Care must be used in selecting the setting sand used at high temperatures to prevent sticking.

In Fig. 3 is shown a curve of the temperature rise in this kiln when given the most favorable adjustment. Temperatures of 1850°C have been

[1] Recd. Aug. 20, 1925.

[2] Babcock & Wilcox Fellow, Division of Coöperation and Research, Massachusetts Institute of Technology.

repeatedly reached and held as long as 10 hours. It is believed that an even higher temperature could be reached but the kiln lining deteriorates rather rapidly above 1800°C. The atmosphere in the kiln can be made oxidizing, neutral or reducing until the higher temperatures are reached, then neutral conditions must be maintained.

The temperatures were measured with a Leeds and Northrup optical pyrometer that was checked against a similar instrument with a Bureau of Standards calibration and against a thermocouple calibrated from the freezing points of pure metals. It is therefore believed that the temperatures are correct within 15°C. The value for the maximum temperature is confirmed by the fact that several times brick with a melting of over 1800°C have flowed freely in the kiln.

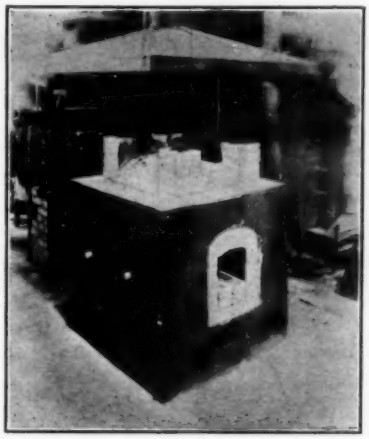

FIG. 2.

It should be noted that the high temperature is attained by the design of the tuyere, combustion space, baffles and flues and not by preheating or heavy insulation. We have constructed a number of furnaces with better insulation, using the same gas and air supply, in which it was impossible to reach over 1700°C.

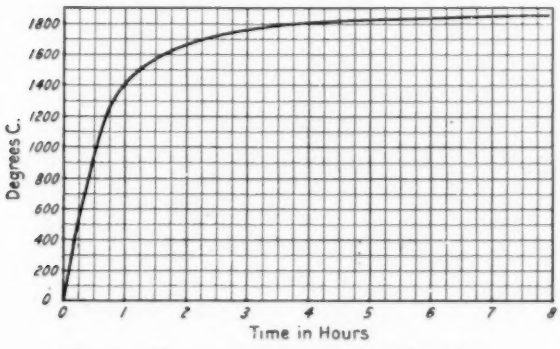

FIG. 3.—Temperature rise in laboratory kiln.

This kiln has been found very useful in the study of refractories, as comparatively large amounts of material such as clays, kaolins and some bauxites can be fused and recrystallized. Materials with higher melting points can be shrunk down to their maximum density. This kiln also gives a large, high temperature field for pyrometer calibration.

While the actual flame temperature reached in this kiln cannot be directly measured, it is estimated from tests at lower temperatures to be at least 50°C higher than the temperature of the walls. This gives a quite conservative figure of 1900°C for the actual flame temperature. This

value is nearly as high as the theoretical maximum values for this gas, which works out by the specific heat equations of Lewis and Randall,[1] to be 2075°C when there is no dissociation.

While it is perhaps a little dangerous to predict the upper limit of combustion temperatures, I think it will be quite evident from the present results that we have not yet reached this limit. Let us suppose that we have refractories capable of withstanding the temperatures, and can preheat the incoming gases to 1000°C (the maximum practical temperature) we should have an increase in the flame temperature of about 500°C. This would give furnace temperatures of 2300°C for the natural gas. With fuel oil even higher temperatures might be expected. Such temperatures are sufficient to carry out most of the commercial electric furnace operations, such as fusing alumina and making silicon carbide.

[1] Lewis and Randall, *Jour. Amer. Chem. Soc.*, **34**, 1128 (1912).

THE MANUFACTURE AND PHYSICAL PROPERTIES OF DRY PRESS BRICK

By J. H. Kruson and C. A. Smith

ABSTRACT

The process of manufacture of dry press brick is described and physical differences between dry press and stiff mud brick are enumerated. The advantages of the dry press process are summed up as follows: (1) they are uniform in size and shape; (2) they have small spalling loss; (3) they have good fusion resistance; (4) their heat conductivity is less than brick made by other processes; and (5) they have a low rate of manufacturing costs.

Introduction

Very few dry press refractory brick were being made twenty-five years ago although one plant in Missouri and two in Ohio have been using this process for at least twenty-five years.

As dry pressing is radically different from hand and machine methods, there naturally has been considerable prejudice and skepticism regarding the value of dry press brick.

The large demand for refractories and the acute shortage of dependable labor, during and after the late war, caused several to produce fire brick by the dry press process and much of the prejudice against them has been removed.

Preparing Clay

Successful manufacture depends largely upon the condition of the clay. There are no set rules for preparing the clay, for each clay and product differs in physical characteristics. The most important factors are: (1) grinding and sizing, (2) moisture content, (3) uniform mixture of clay particles.

Grinding

Grinding is usually done in dry pans, and the screening or sizing over a vibrating or shaking type of screen. The inclined slotted plate screen is used in some localities. The proper sizing of the clay particles is an important factor in the making of a good product but this sizing varies with the physical characteristics of the clay.

Characteristics of the Clay

Moisture Content

In practically all plants all the water required for pressing is added at the dry pan. The water is thus evenly distributed through the clay. Undoubtedly, this method of adding moisture decreases the grinding and screening capacities considerably.

The moisture needed depends upon the type of clay. Some soft, fine clays require from 9% to 12% of water, while the clays of a flinty nature require from 6% to 9%. Some little variation in weight of individual brick may be expected under ordinary working conditions.

The following table shows weights in ounces of brick directly off the press from three entirely different sources:

TABLE I

Sample	No. 1, oz.	No. 2, oz.	No. 3, oz.
A	149	158	143
B	146	154	144
C	152	162	147
D	150	156	140
E	148	160	142

While there was some little variation in weight, these samples when fired were apparently similar regarding size, ring, bond, appearance, etc. There is no doubt, however, but that a large difference in weight would produce brick which, when fired, would differ in quality.

Sizing of Ground Clay

The following shows a typical screen analysis of hard fire clay used by three Missouri companies:

Mesh	No. 1	No. 2	No. 3
On 4	0.00	0.00	0.00
4–6	0.06	0.00	1.10
6–10	11.70	8.10	16.90
10–14	25.50	21.20	26.20
14–28	27.50	24.50	29.10
28–35	13.30	16.80	9.20
35–48	7.40	11.40	6.10
Through 48	14.10	17.30	11.20
	99.56	99.30	99.80

Pressure

The pressure necessary to form a substantial bond in a pressed brick depends entirely upon the nature of the clay. Many soft, naturally fine clays and shales require little pressure, while a hard flint or a mixture high in non-plastic materials demands an enormous pressure (around 5000–6000 pounds per square inch or more).

Drying

The strength of the unfired pressed brick will permit placement directly into the kiln off the press, whereas all stiff mud brick must be dried before any weight can be placed upon them.

The drying, whether done in the kiln or a drier, is much more delicate than the drying of most mud brick and tile.

Watersmoking

Many dry press brick are watersmoked for six to ten days. This depends entirely upon the physical characteristics of the clay. In general, Missouri fire clays are almost fool-proof if just ordinary care is exercised in the drying and firing. Several manufacturers are setting the brick direct from the press, drying

and firing in periodic kilns in from six to seven days and getting excellent results. Others run their brick through driers. However, their firing time and coal consumption is but little different.

Personally, setting the brick directly from the press is preferred. Induced or forced draft is advisable when brick are dried in the kiln.

Firing After the watersmoking is completed, there is but little difference between the general firing procedures for stiff mud and dry press brick from the same clay, other than a temperature of $1^1/_2$ to 2 cones (50–75°F) higher and an additional 12 to 24 hours longer on high fire or soaking period for the dry press. The additional time and temperature naturally consume from 150 to 200 pounds of coal per M brick more than for stiff mud products.

Physical Differences between Dry Press and Stiff Mud Brick

The general differences between brick of similar analysis and clay characteristics from the dry press and stiff mud methods of manufacture may be readily appreciated from the following:

Standard test	Dry press	Stiff mud
Spalling	2.3% per dip	3.5% per dip (as received)
Calculated from total loss and total no. of dips	3.3% per dip	3.6% per dip (on reheating)
Volume change	0.11%	0.21%
Upon reheating at 1400°C	Expansion	Expansion
Slag penetration	1.5 sq. in.	0.60 sq. in.
Load test	1.8% Deformation	2.7% Deformation
Porosity	17.0%	12.5%

The more open or less dense structure of dry press brick is clearly shown by its greater porosity, slag penetration and by its lower spalling loss. The lower volume change of dry press brick upon reheating at 1400°C also shows the lower density of the structure, although it should be pointed out that this test has not been found reliable. The values determined by it do not seem to always hold under actual service conditions in practice and this test is now generally used only as a preparatory step for the spalling test.

The load test shows that the coarser grained dry press brick develops a lesser degree of vitrification than the finer grained stiff mud brick, and that the coarser grains have been firmly pressed together in the manufacturing process, forming a rigid skeleton or framework which resists a steady pressure quite well.

With some clays, the refractoriness of the product may be increased one or two cones by the use of the dry press process, since vitrification does not develop as swiftly in the coarser grained dry press brick as it does in the stiff mud brick.

Advantages of Dry Press

The brick produced by each of the different processes have properties which fit them better for some service conditions than for others. The advantages of dry press brick are several:

(1) Dry press products are always more uniform in size and shape, thus enabling them to be laid up better and with less labor cost, using thinner mortar joints and getting longer life from the installation, due to less tendency for shrinkage and corrosion in joints.

(2) The spalling loss is considerably less than that of brick made by other processes.

(3) Dry press brick resist fusion better than other brick made of same clay, due to slower development of vitrification.

(4) The conduction of heat through dry press brick is less than through brick from other processes, thus reducing the heat loss through the walls.

(5) Dry press brick are cheaper to manufacture, due to lower labor, machinery and drying costs.

Dry press brick are not suitable for service where they will be subjected to severe abrasion, mechanical shock or slag action and greater care must be taken in handling them during manufacture and shipping, due to the sharp edges becoming battered.

Some of the applications of dry press brick are high duty boiler settings, oil refining stills, annealing furnaces (car type), forging and welding furnaces, ceramic kilns (tunnel and periodic), regenerative furnaces (side walls and conducting flues), ladle brick and puddling furnaces (upper side walls).

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OPERATING CONDITIONS IN THE OPEN HEARTH AS THEY AFFECT THE LIFE OF REFRACTORIES

By Charles A. Smith[1]

ABSTRACT

A discussion of the deterioration of refractories under operating conditions of the acid and basic types of open hearth furnaces is given.

Introduction

The object of this paper is not to develop the subject in great detail, but to point out the more salient features of the deterioration of refractories under common operating conditions of the open hearth. The construction of the acid and basic types is practically the same with the exception of the hearth, which must of necessity be acid in the one case, and basic in the other.

Acid Open Hearth

Due to the entire lining of the acid furnace being of the same chemical nature as the slag, which is relatively small in amount, and since no volatile fluxes are added to the charge, the life of the acid furnace is much greater than that of the basic, being frequently 1000 heats. The chief active corrosion of the acid furnace lining results from iron oxides attacking the silica hearth at the edges of the bath where greatest oxidation occurs, and from the scorifying action upon the hearth of molten metal, oxidizing as it is being melted. Steel scrap if charged on the hearth, will attack the hearth greatly in melting due to the large percentage of oxide in the scrap.

Basic Open Hearth

The life of the basic open hearth is much less than that of the acid hearth, being rarely over 350 heats. The relatively shorter life of the basic furnace may be ascribed to the fact that a large part of the lining is of a nature chemically opposite to that of the thin, highly corrosive, basic slag and the furnace atmosphere which is heavily laden with highly basic vapors, flux dust and slag particles.

Ports and Flame Action

The silica roof, the ports, and the checkers, are generally the determining factors in the life of a furnace, and of the three, the ports and the roof are the most troublesome.

While the customary American port design, consisting of a long, narrow air port directly above a much smaller gas port, produces a fast working furnace and allows better combustion without danger of burning the port at the out-going end, the arch forming the gas port is subjected to high temperatures by the gas on one side and the air on the other, thus affording

[1] Refractories Fellow, Lehigh University, 1923.

no opportunity for cooling. These conditions produce failure of the nozzle, or end of the gas port, and cause the flame to be thrown upon the walls and roof of the furnace.

In order to prevent the local overheating and consequent failure of brickwork resulting from this lack of flame control, water-cooled steel ports have been introduced with a fair degree of success. This type of port is of the same general form as the ordinary brick arch port and is inserted through the end of the furnace, being protected by a permanent silica brick arch closely conforming to the outer shape of the metal port.

In some cases the end of the brick arch consists of magnesite brick in order to withstand the action of slag splashes, although magnesite brick spall excessively at this position due to the water cooling.

The ports are so constructed that the flow of gas and air should strike the level bath at a slight angle, and the intensely hot radiant flame should pass through the furnace close to the bath and be separated from the roof by a blanket of cooler air. But during the melting process the furnace is piled high with steel scrap, which forms an excellent baffle from which the flame can be deflected strongly against the roof and side walls. Due to the swirling action given the gases by the incoming air impinging sharply on the top of the gas flow, very hot eddy currents are produced at the side walls opposite the "spotting" point of the flame, if the furnace is slightly narrow. This causes a very heavy corrosive action on the side portion of the roof and lower side walls, in some cases necessitating the building of a roof having a 9-inch center and 12-inch sides in order to prevent the dropping of the entire roof.

Frequently while repairs are being made on parts of the gas producers of a furnace designed to burn producer gas, an oil burner is inserted through a gas port. When a furnace of this type is operated on oil, the life is often reduced about 50% due to the roof being much too low for the intense heat generated by the oil flame. If the roof be raised several feet, a very fast working furnace is produced by oil firing and the flame action is distributed to all parts of the furnace, instead of largely to the roof. The oil-fired furnace has a much shorter life than the gas furnace but the increased production offsets the cost of rebuilding.

Powdered coal has not been found to be desirable as a fuel in a regenerative furnace due to the immense accumulation of ash collecting in, and also fluxing the checkers.[1]

Roof

While the acid nature of the silica roof is entirely unsuited to withstand the fluxing and scouring action of the gas, which is heavily laden with

[1] R. H. Landis, "Pulverized Coal in Open Hearth Work," *Iron Age*, **112**, 1721–3 (1923).

abrading and fluxing particles, silica is used because of its relative cheapness and ability to withstand the excessive temperature, which frequently is in the region of 1700°C. Silica brick are used, due to their property of withstanding the high pressure of the flat-arched roof, up to a point close to the melting temperature. Also the high heat conductivity of the silica brick allows the outer portion to remain firm and rigid even if the inner portion is fused. It is common practice to use a silica roof until it is reduced to about 3 inches in thickness. On examination the iron-impregnated lower portion of a roof brick clearly shows the strong fluxing action of the iron and other basic oxides in the furnace gases.

Side Walls

The silica side walls are subjected to the direct slagging action of the highly corrosive basic slag at or near the slag level in addition to the scouring and fluxing of the gases. The load carried is merely that of the wall itself, due to the weight of the roof being carried by a special steel framework built around the furnace. The brickwork is subjected to considerable thermal shock during charging and after tapping, especially near the doors, which are then wide open and admit large amounts of cold air. Magnesite and chrome have not been very satisfactory for this reason, due to their strong tendency to spall. The direct action of the slag is great, and the lower portion of the side wall from a few inches above the slag line down, is sometimes made of a very high quality chrome brick in preference to several courses of chrome separating a lower portion of magnesite from the upper portion of silica.

In the construction of 200-ton tilting furnaces for the "Talbot" process, the basic lining must necessarily be carried up the side walls for a considerable distance to prevent slag action on the walls during tilting. Frequently, in this type of furnace, the wall on the tapping side is made entirely of magnesite. Since much of the metal is charged molten, and, therefore, quickly charged, and since repairing the bottom takes less time due to the tilting action, the sudden cooling of the brickwork by air currents and the resultant spalling is materially reduced.

Hearth

While the hearth is corroded by the slag, especially at the highly oxidized edges of the bath, it can be and is patched after every melt, and consequently the corrosive action is less important than in other parts of the furnace. The hearth must, however, be highly resistant to abrasion and mechanical shock and must be able to withstand the loads charged upon it. The structure must be dense and firm throughout the range of temperatures used, in order to prevent the absorption of metal and slag, thus lowering its refractoriness.

The formation of cracks resulting from mechanical shock is highly undesirable, since it allows a passage for the metal to work down, and as a result, large sections of the bottom may work loose and allow the molten metal and slag to eat through the steel shell supporting the structure. The chief trouble with the hearth occurs in the formation of holes or depressions which may result from mechanical shock, thermal shock, or improper sintering.

Bulkheads

The bulkheads may be termed that portion of the end of the hearth which extends up to the gas port. The service conditions are different from those of the hearth, the corrosive action of the slag itself being accompanied by the scouring and fluxing action of particles in the exit gases, and there is considerable direct flame action in addition. Material is not charged in this portion of the furnace and therefore the mechanical shock is not important.

Slag Pockets and Uptakes

The uptakes and slag pockets leading from the gas and air ports to the regenerators are generally built of silica brick, even though the gases passing through them carry highly basic particles and flux the brickwork greatly. Magnesite is not used extensively, due to spalling action resulting from the repeated heating and cooling during reversals. However, in some cases, it is used directly back of the ports in the top of the uptakes. The outgoing combustion gases may be at temperatures of 1500–1650°C, while the preheated incoming air and gas, upon reversal, are at from 1000–1100°C at the top of the uptake. Thus, the temperature, abrasion and basic fluxing action are great throughout the uptakes and slag pockets. In addition to the above reactions, the incoming gas in the gas flues is of an extremely reducing character which is of importance in the selection of a suitable refractory.

Regenerators

The regenerators are used not with the primary idea of saving heat, but with the purpose of obtaining a high flame temperature, *i. e.*, a high difference of heat potential between the combustion gases and the furnace charge. The temperatures are such that fire-clay brick can be used for the checkers. The waste gases enter the regenerator at from 1300–1500°C and leave at from 400–600°C. The chief requirements of the brick used as checkers are: that they must absorb and give up heat readily, must not glaze, and in the gas checkers, brick high in iron should not be used, due to the disruptive action of the carbon deposited by the CO in the gas. Although properly designed slag pockets remove a large part of the slag and flux particles from the gases, a considerable amount of dirt

collects in the checker flues. Numbers of special flue designs have been tried with varying degrees of success. In a plant in which standard 4.5″ x 4.5″ x 10.5″ brick checkers had to be cleaned after 145 heats, the same chamber filled with $5^1/_2$″ vertical flues using 13.5″ x 6″ x 2.5″ shapes, lasted 1800 heats before cleaning and gave satisfactory heating service. The increased life was due to the shapes being laid on the 2.5″ side and thus only this series of narrow edges were presented at the top of the checkerwork for the collection of flue dust.

General Considerations

The service conditions obviously must be of first importance in the selection of refractories for various uses in a furnace, and many of them are definitely known but it must be remembered that it is rather difficult to determine the exact conditions of gas composition, temperature and fluxing by fume and small slag particles, and not much exact information of this kind is available at present.

Of the different grades of steel, high carbon steel is least severe to the open hearth since the slag is neither as oxidizing nor is the time as long as in a low carbon steel process. Since the melting temperature decreases and fluidity of a steel increases with the carbon content the production of low carbon steel requires either a furnace temperature several hundred degrees higher than the high carbon steel process, or a much longer treatment, and greater wear and tear of the furnace results. If a charge of 75% scrap and 25% pig be "melted down soft," thus producing an extremely corrosive slag and a heavy oxidation of the scrap, the slag corrosion resulting is quite severe especially in the acid hearth furnace. If an extremely active slag is not used, the time of the operation must be increased in order to remove the carbon, and the furnace wear and tear is correspondingly increased per heat.

If a large quantity of pig iron is used, its quick oxidation by the ore added causes much more splashing of slag on the lining than when lower amounts of pig iron are used.

The practice of carrying at all times 0.15 Si and 0.20–0.40 manganese as residual silicon and manganese in the bath in order to keep oxygen out of the final steel, removes the oxidizing layer of the bath between the metal proper and the slag, and thus materially decreases the corrosive action at the shallow edges of the bath.

In the final analysis, the refractory which is most desirable from the steel maker's point of view is that which will enable him to produce steel at the lowest furnace cost per ton. If by frequent renewals of lining at a fairly low price, a fast working furnace will produce a production large enough to offset the cost of new linings, that operation is satisfactory.

If a higher priced refractory will permit the furnace production to be sufficiently increased to result in a lower or equal furnace cost per ton of steel, that refractory is desirable.

In conclusion the author wishes to acknowledge and express his appreciation of the aid in obtaining information given him by W. H. Kelley, Refractories Engineer of the Bethlehem Steel Company, and by Bradley Stoughton, Professor of Metallurgy at Lehigh University.

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CALCINING AS AN AID TO GRINDING[1]

By W. M. Myers[2]

ABSTRACT

Experiments show no value commensurate with calcining and of water quenching of quartz.

Fire was commonly used in the early days of the mining industry to soften rock, so that it could be excavated more readily with the crude tools available, and to facilitate the crushing of ores in primitive metallurgical processes. Although gunpowder was first used for blasting in 1627, it was not generally adopted as a mining explosive until a much later date, and the ancient process of "fire-setting" was persisted in until the nineteenth century in some European mines.[3]

Twenty years ago it was customary to calcine some feldspars before grinding, particularly the soda feldspars in the eastern Pennsylvania district. Calcination of feldspar has been largely abandoned, and it is probable that the most conspicuous example of the survival of calcining is in the preparation of flint and quartz for the ceramic industries.

The bulk of the material calcined at present is imported French flint pebbles; a lesser amount of massive quartz is also calcined before grinding. This quartz is used as a filler and as an abrasive, as well as in ceramic wares. The flint is commonly calcined in small bottle-shaped kilns which have a capacity of 15 tons. These kilns are charged with alternate layers of flint and wood, one cord of wood being necessary for 15 tons of flint; the charge is ignited and is allowed to burn for 36 hours, after which the kiln is drawn. The calcined flint is crushed under chaser mills to $^3/_8$ inch and then ground for 6 hours in silex lined tube mills with flint pebbles. Before calcination the flint is a dense, even-textured, tough, gray stone. After calcination it becomes an opaque white in color, and is partially shattered through the development of fractures which apparently should greatly facilitate grinding.

The quartz which is calcined is coarsely crystalline and consists of nearly 100% silica. The flint is cryptocrystalline and generally contains about 98% silica. A typical flint analysis is as follows:[4]

Silica	98.16%	Magnesia	0.20%
Alumina	.25	Soda	.20
Iron oxide	.05	Potash	.24
Lime	.50	Loss on ignition	.52
			100.12%

[1] Published by permission of the Director, Bureau of Mines, Department of the Interior.

[2] Associate Mineral Technologist, Non-metallic Minerals Station, Bureau of Mines (in coöperation with Rutgers University, New Brunswick, N. J.).

[3] Hoover, "De Re Metallica, Agricola," p. 118.

[4] Analysis from Golding Sons Co., Trenton, N. J.

Calcination causes no change in chemical composition other than removal of the material lost on ignition and complete oxidation of the small amount of iron present.

It was stated by one of the largest producers of calcined flint that the cost of the operation for both fuel and labor averages one dollar a ton. In order to determine if this calcining cost is warranted a considerable number of comparative grinding tests were made.

The calcined flint used in these tests was obtained from a commercial kiln where it had been subjected to the usual 36-hour burn. Uncalcined flint pebbles having the same dimensions were selected from the same source. These materials were crushed in a jaw crusher and then ground in a small pebble mill with flint pebbles and the various products sized at intervals to determine the grinding efficiency. Care was taken to have all conditions affecting the grinding of the two materials identical. The pebbles were fed directly to the jaw crusher which was set to have a gap of $^1/_4$ inch. A sized feed, 14 to 28-mesh, was prepared for the pebble mill so that the materials would be identical in size at the beginning of the pebble mill grinding. This size was found to be best suited to the capacity of the mills.

In commercial work flint is rarely quenched but is permitted to cool in the air. Quartz, however, is frequently quenched with cold water. To determine the effect of quenching, a batch of flint pebbles was calcined in a muffle furnace and divided into two portions, one of which was quenched while hot by immersion in cold water; the other was permitted to cool slowly in the air. The quenching shattered the flint considerably and the quenched product broke more readily in the jaw crusher so that a smaller amount of the coarsest material was produced than was formed from the unquenched flint. In the smaller sizes little difference was noted, and further grinding in the pebble mill showed little difference in their grinding properties.

These figures show that the grinding efficiency of flint is considerably increased by calcination apparently because of the inversion of the quartz from α to β form at 575°C and the accompanying volume change of over 2%.[1] This volume change produces minute fracturing and furnishes planes of weakness along which the flint separates. Quenching aids only by producing the coarsest fractures. The increase in grinding efficiency is most marked in the material ground in the pebble mill for six hours. After this grinding 92.8% of the calcined flint passed a 325-mesh screen while only 70.1% of the uncalcined material could pass this screen.

The results are tabulated in Table I.

Definite information is lacking concerning what temperature is attained

[1] W. L. Shearer, "Effect of Flints on the Thermal Expansion of Some Whiteware Bodies," *The Ceramist*, [6], 143–65 (1924).

TABLE I

Mesh	Jaw crushers, 1/4-inch gap				Pebble mill, original feed, 14 to 28-mesh					
					At end of 1 hr.		At end of 3 hr.		At end of 6 hr.	
	Laboratory calcined flint, %	Laboratory quenched flint, %	Uncalcined flint, %	Commercial calcined flint, %	Uncalcined flint	Calcined flint[1]	Uncalcined flint	Calcined flint[1]	Uncalcined flint	Calcined flint[1]
+ 4	70.6	64.2	75.8	67.9						
− 4 + 8	15.9	20.2	12.5	16.4						
− 8 + 10	4.5	5.6	3.8	5.0						
− 10 + 14	2.8	3.2	2.4	3.0						
− 14 + 28	3.1	3.6	2.8	3.7	30.4	25.4	0.3	0.1	0.0	0.0
− 28 + 35	1.0	1.1	0.8	1.3	25.2	26.9	1.2	0.1	0.0	0.0
− 35 + 48	0.6	0.7	0.5	0.8	13.4	14.4	6.8	0.9	0.0	0.0
− 48	1.5	1.4	1.4	1.9						
	(100.0)	(100.0)	(100.0)	(100.0)						
− 48 + 65					9.2	9.9	22.3	11.8	0.0	0.0
− 65 + 100					5.8	6.4	16.4	25.1	0.1	0.0
−100					16.0	17.0	53.0	62.0		
					(100.0)	(100.0)	(100.0)	(100.0)		
−100 + 150									2.5	0.1
−150 + 200									9.7	1.1
−200 + 250									5.8	1.0
−250 + 325									11.8	5.0
−325									70.1	92.8
									(100.0)	(100.0)

[1] Material for these tests was commercially calcined.

in the kilns. It probably varies greatly but can hardly be expected to exceed 800° or 900°C. Attainment of higher temperatures would increase the expense of calcination and might have an undesirable tendency to produce cristobalite.

The balance of the increased efficiency in grinding against the cost of calcining appears to be a close one. The crushing of uncalcined flint is complicated by the toughness and the shape of the pebbles and also by the necessity of avoiding any contamination by metallic iron. A jaw crusher with manganese steel jaws should crush the flint satisfactorily to a suitable size for pebble mill feed and could be substituted for the chaser mill. This has already been done in modern feldspar mills. The increased efficiency of grinding calcined flint in the pebble mill does not appear to be sufficiently great to warrant a calcining cost of a dollar a ton. The difference, however, is too small to justify any extensive alterations in plants now in operation. The difficulty of crushing uncalcined flint pebbles with a chaser mill may be the chief reason for adhering to the calcination method. A decrease in the use of chaser mills and the employment of more modern crushing equipment may be expected in the future, and it is probable that this use will be accompanied by a decline in the practice of calcination.

SHALES OF NORTH CAROLINA[1]

By Jasper L. Stuckey

ABSTRACT

North Carolina contains several extensive areas of shale deposits, which are favorably located for working and which in their slightly weathered condition have been recently found to be well adapted to the manufacture of face brick, hollow blocks, sewer pipes, etc.

As a result of these discoveries a number of clay working plants have been recently set in operation and others are in course of construction.

For a number of years North Carolina has been one of the leading states in the production of high-grade residual kaolin such as is used in the manufacture of china, porcelain and spark plugs, but it is not ordinarily thought of as containing deposits of shale suitable for the manufacture of face-brick and high-grade heavy clay products, and in the literature very few references to North Carolina shales are to be found. Ries[2] pointed out, in the second edition of his textbook on clays, that a weathered shale was being used at Pomona, Guilford County, for the manufacture of sewer pipe and further stated that Triassic shales were known to occur in the state, but that little was known of their value for making clay products.

In the reports of the State Geological Survey considerable space has been devoted to clays and clay products, since 1897, but the first reference to shale was published in 1914.[3] This report pointed out that this material was then used in Guilford County and that plans were being made to develop a shale deposit in Madison County a short distance west of Asheville.

Due possibly to the abundance of timber in the state and also to the fact that the methods in use at the various brick plants of the State were suited to the use of clay and not readily adapted to the use of shale, little or no progress was made in its application until after 1920. About this time both the brick makers and the users of clay products realized that all the face-brick and high-grade heavy clay products used in the state were being imported and that with building going on at such a rapid rate the State would be a heavy loser in the added cost of clay products used in building unless these materials could be manufactured at home. This loss was even more evident to the brick makers who were feeling the demand for a high-grade product. Consequently during the years 1921 to 1924 investigations of the shale resources of the State were made by the more

[1] Recd. Aug. 14, 1925.

[2] H. Ries, "Clays, Occurrence, Properties and Uses," 2nd ed., N. Y., 1908 (John Wiley and Sons).

[3] "The Mining Industry in North Carolina during 1911 and 1912," N. C. Geol. Survey, *Economic Paper*, **34** (1914).

progressive manufacturers, encouraged and assisted to some extent by the State Geological and Economic Survey. This work has been materially increased during 1924–25 by the help of the Department of Ceramic Engineering of State College, Raleigh, N. C., under the direction of A. F. Greaves-Walker.

The results of these investigations have shown that there are in the State deposits of shale, which, although small when compared with those of such states as Pennsylvania, New York and Ohio, are more than adequate to meet the needs of the State once they are properly utilized.

When referring to shale it is to be understood that the material used is in at least a slightly weathered condition, which tends to increase its plasticity. The absolutely fresh rock, especially that of the slate belt, is of doubtful value. The change due to weathering apparently extends to a depth of 30 to 50 feet.

The map (Fig. 1) shows the general distribution of those geological formations in the State which contain shales that are now considered

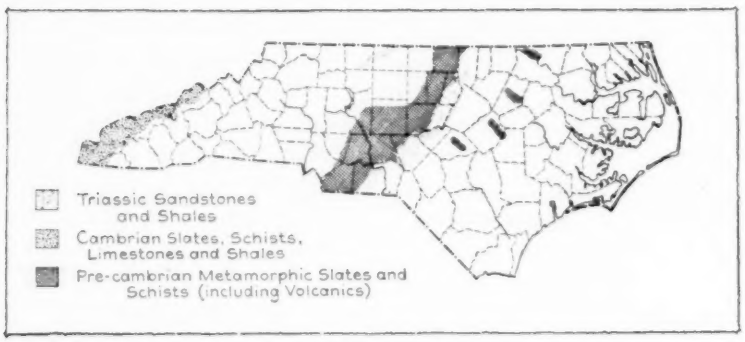

Triassic Sandstones and Shales
Cambrian Slates, Schists, Limestones and Shales
Pre-cambrian Metamorphic Slates and Schists (including Volcanics)

FIG. 1.—Map showing distribution of shale in North Carolina.

of commercial value. These shales, which belong to three different geological formations, are found in four areas conveniently located to all parts of the State. These known areas are: (1) The pre-Cambrian slate belt of the central part of the State, particularly that portion of it in Davidson, Stanly, Anson and Union Counties; (2) The Cambrian shales near Hot Springs, Madison County; (3) The Triassic shales of the Dan River Coal Field in Stokes and Rockingham Counties; and (4) The Triassic shales of the Deep River Coal Field in Durham, Chatham, Lee, Moore and Anson Counties.

Pre-Cambrian Shales of the Slate Belt

The largest area of shales in the State and the one that has been best investigated and developed for the face-brick industry is that of pre-

Cambrian slates, commonly known as the "Slate Belt," which crosses the central part of the State in a northeast to southwest direction. This area has long been of scientific interest and was early recognized by geologists as of pre-Cambrian age, but it was only recently that its value as a source of shale for high-grade products was discovered. The formations of the area consist of a great volcanic-sedimentary series made up of long bands of shale, composed in part of volcanic ash and in part of land waste. The whole series has been so completely metamorphosed over most of the area that the shales have become slates with a well defined cleavage, which has in most cases destroyed the bedding planes. In parts of Stanly, Anson and Union Counties metamorphism was less severe and as a result cleavage planes are not so well developed while the bedding planes have been very little disturbed leaving large areas of shale little altered and almost horizontal. This part of the area is most important as a source of shale. Weathering has attacked the shales to great depth so that in most places they are fairly soft and readily worked.

These shales first began to attract attention in 1921 when two or three companies, particularly those at Norwood and Monroe, which had been using surface clays and making common brick, investigated the underlying shales, found them of value and began converting their plants into modern face brick plants.

In January, 1922, the Winston-Salem Southbound Railroad had shales collected from seven possible plant sites along its line in Stanly and Anson Counties and tested by Ellis Lovejoy[1] at Columbus, Ohio. The report of these tests shows that six of these shales have a firing range of 7 to 9 cones (1958° to 2246°F) for a good red color and hard product. All the shales are reported as working well in machine tests, but require a maximum amount of pugging to get the best results. In the wet state they are weak, and cannot be classed as strong in the dried state as compared with other clays and shales, but they have ample strength to withstand all the weight in the kilns to which the bottom brick are subjected. The drying behavior of all the shales tested is excellent. The drying shrinkage of the different samples varied from 1% to 5%. The firing shrinkage is greater and inclined to be high. In one sample it varied from 1.1% at the lower temperature to 8% at the higher temperature and was classed as almost ideal. In the other samples it varied from about 1% at the lower temperatures to 11.5% to 13.3% at the maximum temperatures. The six shales tested have a long safe firing range for a steel hard product and good red color. A vitrified product is possible but not encourag-

[1] Ellis Lovejoy, Lab. Test No. 3110. Report of the result of test of shales between Whitney and Ansonville, North Carolina along the Southbound Railway, for the Winston-Salem Southbound Railway Company, Winston-Salem, N. C. Used by permission of the President of the Winston-Salem Southbound Railway.

ing for a paving brick. The conclusion of the report is that these shales are ideal for brick, hollow blocks up to 5 x 8 x 12 inches, and drain tile up to a diameter of nine inches.

Actual usage at the different plants shows that the shale can be readily made into good common brick and face brick if properly handled. No attempt is at present being made to manufacture any other product. The shale is weak in the wet state but not to such an extent as to require detailed preparation. A dry pan for grinding, and thorough pugging have been found entirely satisfactory. The shrinkage is often high but this can, with proper handling, be overcome. No trouble is found in firing the weathered material, but the harder (less weathered) layers, however, are more difficult to handle due to the fluxes present, and because of their frequently short firing range which is often not over 50°F. This less weathered material will often not stand over 1850°F.

The shale fires a deep red color and makes ideal face brick of the variegated color so much in demand now. Beautiful colors are produced naturally, and by flashing and the use of chemicals the range can be easily and considerably increased. These shales will doubtless make good drain tile of the smaller sizes, building tile, and floor and roofing tile if the shrinkage is properly cared for.

Four modern shale brick plants, with round down draft kilns, located in Davidson, Stanly and Union Counties in the southern part of this area will produce in the year 1925 at the present rate of manufacture a minimum of 40,000,000 face brick.

These developments are just beginning to indicate the value of the shales in this district. The supply in the southern half of the area is large and any number of suitable plant sites can be found convenient to railroad transportation. Little is as yet known about the northern half of the belt where the shales are more highly metamorphosed.

Deposits of this same type of shale that are interesting and may prove of value are also known in Harnett, Johnson, Nash, Halifax and Northampton Counties.

Cambrian Shales

Formations of Cambrian age are found in a number of localities in the western part of the state, the most important shale deposits of this age being found in Madison County near Hot Springs. These shales are conveniently located near the main line of the Southern Railway from Asheville to Knoxville, Tenn., and have been known for several years. An attempt to work them in 1917–19 proved a failure due to the lack of proper equipment. The shales are red firing and appear to have good working qualities and will doubtless prove of considerable value for heavy clay products when they are properly worked.

Triassic Shales—Dan River Coal Field

A belt of Triassic rocks about five or six miles in width, commonly known as the Dan River Coal Field crosses Stokes and Rockingham Counties in a northeast-southwest direction. The formations consist of interbedded sandstones and shales which dip from 30–65° to the northwest. Important shale deposits varying from a few feet to 300 feet in thickness are abundant throughout the area. Due to the attitude of the beds it is comparatively easy to open a shale pit on any one of them and work along the strike.

This was the first shale area in the state to be successfully worked. For a number of years the Pomona Terra Cotta Company at Pomona, Guilford County, has been getting its supply of shale from beds in this area near Madison, Rockingham County. Pits have been worked to a width of 60 feet, a depth of 40 feet and from a few hundred to 2000 feet along the strike.

The shale is dug by steam shovels, loaded into gondola cars and shipped 30 miles to Pomona where this Company has the largest and best equipped sewer pipe plant in the South. The works now consist of four modern sewer pipe plants, with 44 round kilns, having a capacity of approximately 5000 tons of sewer pipe per month. A high grade vitrified product that will pass all A.S.T.M. specifications on absorption and crushing strength, is being produced.[1]

In the same area at Pine Hall, Stokes County, the Pine Hall Brick Company is producing a high grade face brick. This Company has a thoroughly modern shale brick plant with a capacity of about 20,000,000 bricks a year.

These shales are naturally soft and work exceedingly easy. They have a low shrinkage, are red firing, and produce a dense body of pleasing color at temperatures around 1850–1900°F. They are well suited for face brick, with a wide range of natural colors, as well as sewer pipe, drain tile, hollow building tile and other clay products. The quantity of shale available in this area is large and well supplied with transportation facilities.

Triassic Shales—Deep River Coal Field

The most promising and least developed shale area in North Carolina is the Deep River Coal Field of Moore, Chatham and Lee Counties with its extension to the north and south.

This area is some 12 miles wide and 75 to 100 miles long with Sanford, Lee County, as its center.

The formations consist of interbedded sandstones and shales of Triassic age, which vary in thickness up to several hundred feet and dip from

[1] A. F. Greaves-Walker, N. C. State College of Agriculture and Engineering, *N. C. Agric. and Indus.*, **2** [11] (1924).

20–60° to the southeast. The dip of any given bed makes mining in most cases extremely easy.

Considerable interest is being shown in the shales of this area. Two plants near Sanford are making excellent brick while two plants for the manufacture of hollow building tile are in the process of erection. The Carolina Fireproofing Company, Charlotte, N. C., is completing a plant near Gulf. The kilns will be fired by producer gas made from coal obtained at the near-by mines on Deep River. The Borden Brick and Tile Company, Goldsboro, N. C., is building a modern tile plant near Sanford, Lee County.

The shales of this area are red firing and develop an attractive color in the kiln. They are naturally soft and have unusually good working qualities and low shrinkage. At the low temperature of around 1800°F they fire to a dense body with a clear ring. At the plant of L. C. Isenhour near Colon, Lee County, the typical shale has a shrinkage of 1 to 4% and fires to an excellent red color and dense body with a clear ringing sound at 1750–1800°F. These shales are well suited for the manufacture of common and face brick, hollow building tile, drain tile and sewer pipe. The area contains an abundance of shale with a large number of plant sites readily accessible to railroad transportation.

North Carolina has in the past obtained large quantities of face brick and high-grade heavy clay products from other states. In the near future however, with proper utilization of the shales of the state as they are now known, producers should be furnishing practically all the clay products needed at home and also shipping to the neighboring states.

Department of Conservation and Development
Raleigh, N. C.

INTRODUCTORY STUDY OF THE PUGET SOUND SHALE AND GLACIAL CLAYS[1,2]

By Thad. O. Smith

ABSTRACT

Type and character of clays of Puget Sound are described.

Geologists tell us that a million or more years ago an older mountain range stood in the present location of the Cascade mountains. On the western side the lower elevations were covered with swamps, lakes and shallow arms of the ocean. Rank growing vegetation and a tropical climate existed. In the course of time, as the mountains were weathered and eroded, clay was formed, carried down by the streams and deposited in the shallow waters along with the rotting vegetation or carbonaceous material. These sediments increased in thickness, were subjected to pressure resulting from their own weight and later crustal movements and have been tilted, faulted and broken until we have the present shale, sandstone and coal beds of Pierce and King counties.

A certain amount of intermingling occurs between the three types of sediments. The carbon, sand and clay content of each is subject to wide variation. Because of the carbonaceous matter in the shales, a large part of the iron is usually in the ferrous or reduced condition and tends to give the burned shale products a brown instead of the deep red shades. The clays and shales which have been lying out in the open and have become thoroughly oxidized, such as those found in eastern and southwestern Washington, give better red colors than those which are mined from underground. These shales are exposed in a number of places such as Renton, along the Cedar and Green rivers and at Bellingham. Wherever coal is found, shales can be expected to occur, though they may not always be of sufficient purity to be useful.

The plasticity of the shales as mined is almost a negative quantity. This is due to the tightly packed structure which has been produced by the pressure and some chemical action. If the pressure were continued long enough the shale would become slate. The original plasticity is best restored by grinding with water in a wet pan, as in sewer pipe manufacture, although for most wares, sufficient plasticity is developed by the dry-pan pug mill process.

An analysis of a local shale showed 6% volatile matter, which is a mixture of chemical water and carbon, and about 0.2% sulphur. The latter gives oxidation troubles in the kiln and also is one of the causes of scumming and efflorescence found on the surfaces of the fired ware.

The shales are used in a number of different products but find their best

[1] Recd. Apr. 9, 1925.

[2] Presented at the Pacific Northwest Clayworkers' Association, Jan. 17, 1925.

application in the manufacture of sewer pipe, paving brick, face brick, tile and other structural products. A comparison of the local commercial shales with some eastern United States shales shows that those of the Puget Sound district are vitrified at lower temperatures but have a shorter firing range. This is best shown by a comparison in the following porosity table.

TABLE I

APPARENT POROSITY[1]

Cone	Average Puget Sound shale	Average Puget Sound glacial clay	Purdy's Classification[2]		
			Paving brick	Sewer brick	Bldg. brick
08	33%	33%	29 + %	24–29%	18–24%
06	31	30	26–35	14–26	5–14
04	25	18	19–33	7–19	4–7
02	17	4	18–32	2–18	...
1	9	1	17–31	2–17	...
3	6	Fused	7–13	2–7	...
5	3	Fused	3–6	2–3	...
7	5	Fused	2–4	2–2	...
9	Fused	Fused	1–2	...	...
11	Fused	Fused	1–2	...	...

Puget Sound Glacial Clays

The glacial clays which are very plentiful in the Puget Sound region are of comparatively recent origin, being deposited from 30,000 to 40,000 years ago. After the deposition of the shales, the second or our present Cascade range was gradually elevated into its present position and the climate changed from tropical to arctic. Glaciers crept down from the north and were joined by smaller feeders from the Cascade and Olympic ranges. Two, possibly three, distinct flows occurred, each following three main channels: that of the Sound itself, the Hood Canal route and the third pushed its way from Everett to Snoqualmie. The natural drainage channels were all blocked and numerous lakes were formed from the melted ice. In the quiet waters of these lakes the fine rock flour and suspended clay materials were deposited and have formed accumulations of considerable depth. Many of these lakes have remained until present times and the clay washing process is still continuing at a much slower rate. The second glacial period followed the first after some interval of time, but the ice traveled the same channels to points farther south. The terminal moraines in the neighborhood of Tenino and Olmypia show the extent of the ice

[1] Per cent apparent porosity equals the percentage weight of water absorbed by the fired body in terms of the bulk volume of the piece. The percentage absorption is approximately one-half of the per cent apparent porosity.

[2] Purdy's classification, "Paving Brick and Paving Brick Clays of Illinois," Ill. Geol. Surv., *Bull.* **9**, 275 (1908).

sheet. These vast accumulations of sand gravel and clay were carried in part down the Chehalis river valley but the remainder served to block the water from the melting ice. The larger lakes were drained through the straits of Juan de Fuca after the retreat of the glacier to the north. The sediments exposed have received comparatively little pressure and show no fissile structure as do the shales, but may vary considerably in sand and gravel content. Practically no crustal movements have tilted the beds or changed them from their original positions.

Our blue-gray glacial clay represents the mixing of sediments and rock flour from wide areas of land which the ice has ground to powder by its weight and movement. As the ice passes over a clay or shale formation it will pick up the surface and mix the plastic materials with the non-plastic rock dust. The glacial clays sorted out from such a heterogeneous mixture contain a large amount of very fine sand and hence are not as plastic as one would first think. A sample from a local brick plant gave only 5% sand that would not pass a 200-mesh screen. However, as this is our finest screen, the total amount of non-plastic material was determined by settling the clay in water and siphoning off the plastic or floating material. The settled material was rewashed until clear water could be decanted after one minute settling. The total amount of sand was found to be 40%. However, this is a very necessary ingredient to hold the shrinkage down to normal.

The sand content varies widely in amount in different localities and is made up of a mixture of different minerals. Quartz, lime and soda feldspar and zircon have been identified under the microscope. An analysis of a glacial clay showed 2% volatile matter which consists of both combined water and carbonaceous matter; 0.014% sulphur was present as sulphate while the total content of sulphur was 0.082%. The sulphates are the cause of most of the scumming found on the soft fired brick. The volatile matter found in the glacial clays is much lower than that found in the shales because of the lower carbon content.

Many of the eastern and middle western glacial clays such as those found through Illinois, Indiana and Ohio contain quantities of both finely divided and coarse limestone picked up by the ice as it traveled south from Canada. Limestone if it is not finely powdered causes spalling and popping due to the slaking and swelling of the fired lime in the brick when moisture and carbon dioxide combine with the quicklime. Our local clays give no trouble from this cause unless an occasional clam shell bed is unearthed in the clay pit.

Glacial clay is used extensively for making face and common brick, building and drain tile. The Portland cement companies mix it with ground limestone to make cement clinker and the concrete men use the Portland cement with glacial sand and gravel to produce concrete; hence,

all told, the Portland cement industry in this district is greatly dependent on glacial materials.

For brick manufacture the glacial clays have several advantages and disadvantages: The clays lie on the surface, are easily accessible and are found close to the large centers of consumption. However, in most cases they vary considerably in sand and gravel, usually require some stripping and some method for removing pebbles. They should be mixed in large quantities to preserve a constant uniformity. Much difficulty is experienced by sliding in wet weather, and large quantities of very sandy clay may cover the face of the more plastic material. The glacial clays are soft, grind easily and quickly produce their maximum plasticity. The longer a shale is ground the more plastic and sticky it becomes, and the more water necessary for plasticity. The glacial clays do not have the toughness of the shales, but with their larger quantities of fine sand show more brittleness in the column from the auger machines. Carefully balanced dies are often necessary and thin members are avoided. The vitrification range is very short so that the difference in temperature usually experienced in the large kilns will produce both overfired and underfired brick. The shrinkage on one end of a brick is often much different from that of the other end. Because of the low temperature necessary and the ease of overfiring the glacial clays, wood has been found to be a good substitute for coal. Wood has a long comparatively cool flame which gives better oxidizing conditions and thus produces better red colors than the hotter and more violent coal flame.

Few localities in the United States can furnish clay suitable as slip clays for glazing stoneware, electric insulators, etc. The most prominent are found near Albany, New York, in Texas and Michigan. The Albany slip clays are perhaps the best known and have been formed by glacial action in a very similar fashion to those clays of the Puget Sound district. They have the same blue-gray color when fresh which turns to a dirty brown after exposure to the atmosphere as the iron oxidizes.

Several good mahogany brown slip glazes have been made in the ceramic laboratory with the fine grained local glacial clays mixed with fluxes like feldspar and fired to cones 6–8. Slip clays must not blister or bloat when fused or shrink excessively during the drying period or the early stages of firing.

UNIV. OF WASHINGTON
SEATTLE, WASHINGTON

THE APPLICATION OF PEBBLE OR BALL MILLS IN ENAMELING[1]

By Edw. W. Lawler

ABSTRACT

A description of pebble mills in enameling is given; details of design and results are discussed.

The size of a ball or pebble mill depends on the amount of material to be ground. For one cubic foot of the dry frit, the mill should be four cubic feet inside the lining and two cubic feet of pebbles should be used. The water added should be in about the proportion of 35 to 40% of the frit volume.

The diameter of the mill should not be less than the length. Figure 1 shows a mill 36 inches diameter by 42 inches long. The manhole is in the center and is approximately 15 inches square, so that the distance from the inside of the head lining to the edge of the manhole is about 9 inches. If a 4-inch valve is used as in wet grinding, it will be $14^1/_4$ inches from the ends. In this size mill this is not so bad, but in a mill 8 feet long as in Fig. 2 it is a bad condition as the distance from the head of the mill to the edge of the manhole is 35 inches.

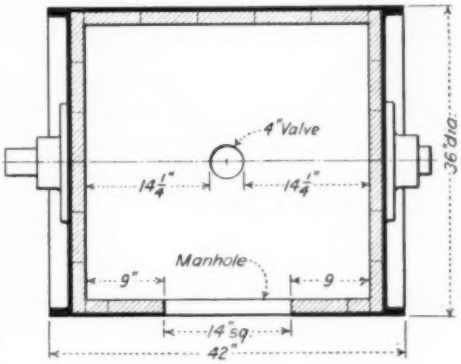


Fig. 1.

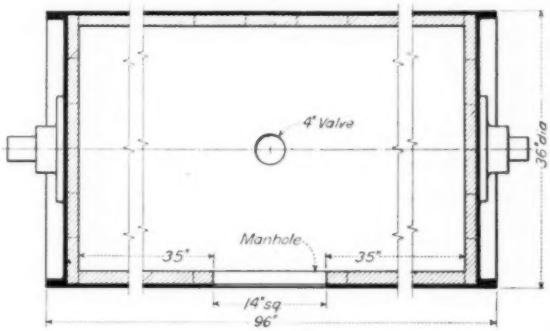


Fig. 2.

In discharging a wet batch, the wet material in the center of a large mill runs out first, while that on each side of the outlet gradually drains out, except that which has settled and separated from the water. This adheres to the pebbles and the lining. If not washed out it will stay in the mill and become part of the next charge. This is the reason the length of the mill should not exceed the diameter.

[1] Presented at the Annual Meeting, American Ceramic Society, Columbus, Ohio, Feb., 1925. (Enamel Division.)

Cylindrical vs. Sloping Sides

A mill with sloping sides overcomes these discharging difficulties. In a mill which has the same cubic capacity but has sloping sides, the diameter can be 42 inches and the length 14 inches. The manhole would extend the entire width of the cylinder. The 4-inch discharge valve would be only 5 inches from the head. Because of the large diameter and short barrel length this mill would grind the same charge in less time than would the cylindrical mill. It would not be necessary to turn it over when discharging a wet batch and in dry grinding practically all of the charge would run out if the mill were left with the grate down. A minimum of revolving would be required and there would be less breaking of pebbles and lining.

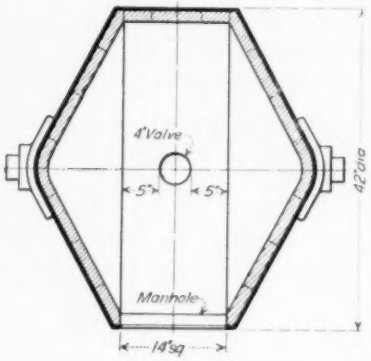
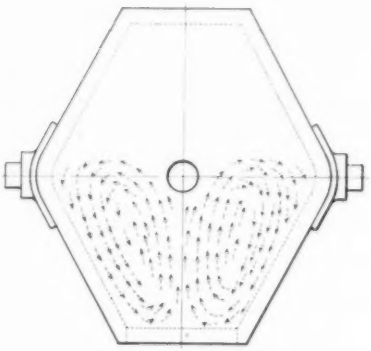


FIG. 3.

The old Alsing mills were 30 inches in diameter by 18 inches long with a manhole the entire width of the mill, a proportion which cannot be improved upon except to increase the diameter.

One of the disadvantages of a cylindrical mill is the flat heads. In a cylindrical mill the head lining is rubbed and worn with a minimum of grinding because the particles of frit do not remain long enough between the round pebbles and the mill head. The sloping sides permit more action of the pebbles per lift of pebbles.



Path of Pebbles in Mill of Sloped Sides

FIG. 4.

The sloping sided mill must have a larger diameter than the cylindrical mill of equal cubic capacity. The cylindrical mill 36 inches diameter by 42 inches is the equivalent of a sloping sided mill 42 inches diameter but only 14 inches wide. The sloping sides are not patented. The advantages of this type mill are obvious and have been proved by two years' operation.

Details of Design

The Manhole

The iron on the manhole frame and the cover of a popular size mill now in use present to the action of the pebbles about 50 square inches of iron. White enamel free from

black spots cannot be ground in this mill. I have seen covers taken off a mill grinding white frit when brown iron water would run down into the charge from the iron manhole. (See Fig. 5.)

The manhole frame of a mill should be flush with the shell of the mill and not with the lining. (See Fig. 6.) Instead of a $^1/_2$-inch cast iron flange, 16-gage brass, steel or other material may be used.

The Lining A mill with the lining half worn grinds better than a new lining because the square corner is now rounded so that the pebbles fit. (See Fig. 7.) A sloping side mill has no corners.

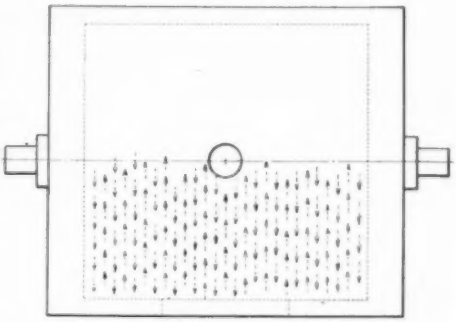


FIG. 4a.

In lining a mill the best porcelain is none too good. I have just relined a number of mills and the old linings were worn in spots right down to the shell while the adjoining brick were almost as thick as the new ones. This is because the brick were of varying hardness. Soft ones wear out first and

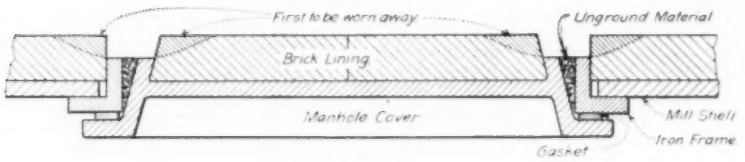


FIG. 5.

new linings are required. Not only does a poor brick wear quickly, but it enters the charge being ground. A hard white porcelain will last longer.

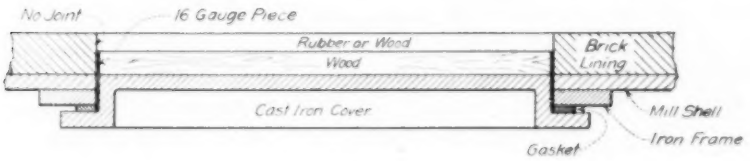


FIG. 6.

A brick with a tongue and groove will not hold in place better, neither will it allow smoother lining. When the lining wears down to the tongue and groove the brick will chip and wear rapidly. A tongue and grooved lining is not easily patched. (See Fig. 8.) The standard keystone shaped

brick is the best and if properly set will not fall out because the cement and shape hold the brick.

A first-class porcelain brick costs at the pottery about $7^1/_2$ cents per pound. A cheaper brick costs $5^1/_2$ cents.

Silex makes a good lining, but it is rough (an advantage), does not fit closely (a disadvantage), and is very hard to fit by chipping. A silex lining properly set is worth the time for it will outlast any lining except possibly rubber.

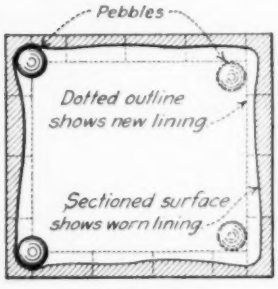


FIG. 7.

Rubber will outwear the hardest steel. I have seen the inside of a tube mill loaded with steel balls after grinding silver for 90 days continuously. Apparently the lining was not worn, though at the beginning it was only $^5/_8$ inch thick. It is patented and put on the market by B. F. Goodrich Co. J. Denny and R. B. Watson discovered its use as a ball mill lining.

As a lining for enamelers' mills, rubber will surpass and displace all other materials for wet grinding. Dry grinding develops heat which might deteriorate the rubber. If it can be fastened in and if it does as well in batch pebble mills as in continuous ball mills, rubber will be the lining most used. A rubber plug on a valve in a mill will outwear the porcelain linings although here the wear is the heaviest and it usually projects into the mill. (See Fig. 9.)

The Balls Balls or pebbles used for grinding are one of the factors that affect the work of the mill more than anything else. Porcelain balls of good quality are white and do not discolor the enamel charge. Porcelain balls have been preferred but it appears to me that a porcelain ball has no advantage over flint pebbles. They are made by hand and present more points of contact than a water-worn pebble. But the flint pebble is harder.

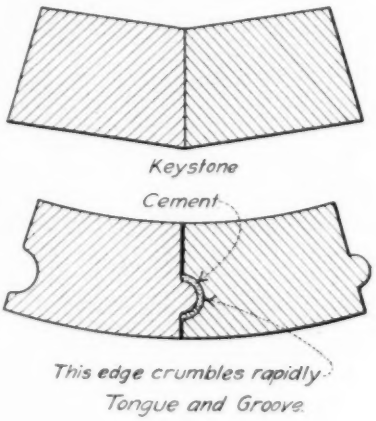


FIG. 8.

The main thing in a grinding body is to concentrate the greatest weight in each within the minimum of surface area. It is for this reason that metal balls do more work than flint pebbles.

Every pebble has a point of contact with as many other pebbles as it can touch and the grinding is done at these points of contact. The smaller the pebble, the more can be put into a given volume. A mill charge that

can be broken down by a 1-inch pebble will, therefore, be ground faster with 1-inch pebbles than with 2- or 3-inch pebbles. Larger pebbles have not as many contact points and cause larger voids.

Loading of a Mill The proper way to load a mill is to fill it half full of pebbles of the smallest size which will do the work. Instead of buying 1-, 2-, 3- and 4-inch pebbles and wearing them down to the right size you had better lease this job to the ocean. It costs less.

New pebbles often are dumped from the bags directly through the manhole without regard to the iron, sulphur or other dirt which the enamelist would not care to see dumped into his enamel.

Considering that bags are used more than once and have been containers for various materials, and that they are porous and have many materials dumped on and in them, care should be used not to have these deleterious foreign materials dumped in a mill with pebbles.

A pebble to do its best work in a grinding mill must take the longest roll from the top of the load and must do this with maximum rapidity. When it reaches the top as the mill is revolving, it is a fight between gravity and centrifugal force. If the mill speed is too high it will cause the pebble to carry too high and drop. If it is not quite high enough the pebble will leave the crest of the pebble wave and sluggishly roll to the bottom.

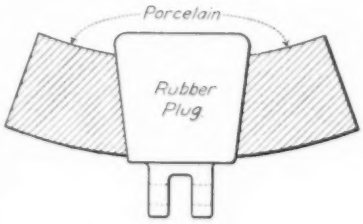


FIG. 9.

The viscosity in wet grinding should be such that the pebble moves freely but not too freely. Too much water causes the pebbles to splash and break. It also washes the material off the pebbles and they grind themselves and the lining instead of the frit. Too little water consumes power up to a point and then decreases the power but increases the time of grinding. It is a simple matter to get the viscosity of the mass right for grinding and add water after grinding if this should be needed for discharging and screening. When the correct amount of water has been determined, a measuring tank holding just that amount should be placed over the mill.

Some claim that the pebbles should roll and not drop vertically but in one plant I know of, they had operated 5 tube mills for ten years at speed sufficient to cause the pebbles to roll. A new manager decided that the drop was better. He speeded up the mills till the pebbles dropped vertically. Now four mills are doing the work which formerly required five mills. In other cases, reducing the speed had no effect on the capacity but lowered the amount of power required. This shows that there is an argument for each method. Checking the operation of the pebble mills may lead to the cause of the troubles and their corrections.

NORTH PLAINFIELD, N. J.

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Zimmerli, F. P.	351
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Abrasives

Loose abrasives standardized. Henry R. Power. *Abrasive Ind.*, **6** [9], 275 (1925).—P. points out the great need for the standardization of loose abrasives as adopted by the Grinding Wheel Mfrs. Assn. of the U. S. and Can. A table is given showing the dimensions and tolerances of U. S. standard sieves. C. J. H.

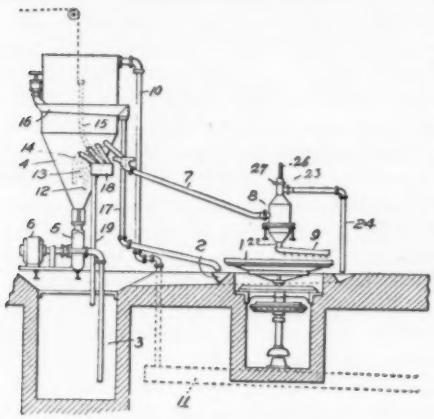
PATENTS

Grinding-wheel bearing disk. Albert M. Leverich. U. S. 1,554,861, Sept. 22, 1925. The combination with a grinding wheel, of a bearing flange having recesses in its inner face, said recesses having their bottoms inclined outwardly and gripping members movably mounted in said recesses.

Article of silicate bonded granules. Clarence B. Tilton and Milton F. Beecher. U. S. 1,555,086, Sept. 29, 1925. The method of making an article of bonded abrasive grains comprising the steps of mixing said grains with dry sodium silicate and a temporary viscous binder and thereafter heat treating a formed mass of said ingredients at a temp. between 850 °C and 1000 °C, to fuse the bond into intimate contact with said granules.

Silicate bonded abrasive articles and process of making the same. Pehr Johanson and Clarence B. Tilton. U. S. 1,555,119, Sept. 29, 1925. A bonded article of granular mat. and a bond comprising dry sodium silicate and liquid sodium silicate set by the application of heat without fusion thereof, said silicate content forming more than 10% by weight of the total mass.

Method and apparatus for making ceramic products. EDWARD ANDERSON. U. S. 1,556,193, Oct. 6, 1925. The method of making a ceramic article, which comprises puddling the constituents of the article, adding a quantity of temporary binding mat., enclosing the puddle in a mold and depositing the mold in an oven, the temp. thereof being then raised to a point sufficiently high to cause the binding material to bind the constituents of the puddle together, and maintained thus until the puddle is dry, the puddle being subjected indirectly to air currents in the oven.



Process and apparatus for applying abrasive to grinding apparatus. CHRISTOPHER BROWN. U. S. 1,556,753. Oct. 13, 1925. The process of applying abrasive to a grinding mach. which consists in collecting the abrasive and water from the mach., returning the mixture to a grader and separating the abrasive into a series of grades, withdrawing therefrom first the coarsest grade of abrasive mixed with water, flowing it to the grinding mach., and eliminating a portion of the water in such withdrawn mixture as it flows from the grader to the mach.

Bauxite. A. M. MCAFEE. Can. 247,771, Mar. 17, 1925. Bauxite is dehydrated and heated by contact with products of combustion under conditions precluding shrinkage and C is catalytically deposited in its pores by exposure to hydrocarbon gases. (*C. A.*)

Art

Decalcomania. I. BERTRAND RHEAD. *Ceram. Ind.*, **5** [2], 149(1925).—History, development, uses and future possibilities—domestic, English and continental practice. *Ibid.*, **II**; *Ceram. Ind.*, **5** [3], 250(1925).—A number of directions are given to obtain best results. F. G. J.

Technical classes in pottery and glass. ANON. *Pottery Gaz. and Glass Trades Rev.*, **50** [579], 1414(1925).—Gives particulars compiled from the prospectuses of schools, etc., as received. The following schools are described: Central School of Science and Technology, Stoke-on-Trent; Cumberwell School of Arts and Crafts, Peckham Road, London; City and Guilds of London Institute, Kensington Park Road, London; London County Council Central School of Arts and Crafts, Southampton Row, London, W. C.; The Woolwich Polytechnic School of Arts and Crafts; Municipal College School of Art, Renfrew St., Glasgow; The University of Sheffield, Dept. of Art Technology, Wordsley Art and Technical Institute, Wordsley, Stourbridge, Staffs. (*To be continued.*) F. G. J.

PATENTS

Coating porcelain or glass with metals. A. F. EIJSSEN. Brit. 229,263, Feb. 15, 1924. Porcelain or glass is coated with brass by rubbing the dulled surface with a small quantity of glycerol by use of a brass brush. Cu may be deposited electrolytically. $AgNO_3$ may be added to glycerol to produce Ag deposits. (*C. A.*)

Cement, Lime and Plaster

Standard specifications for gypsum plastering sand. A. S. T. M., *Yearbook*, **1925,** Serial designation: C 35–25, 25.—Specifications are made as to compn. and as to grading. These specifications were proposed as tentative in 1921 and adopted in amended form in 1925. R. M. K.

Standard methods of making compression tests of concrete. A. S. T. M., *Yearbook*, **1925,** Serial designation: C 39–25, 37–42.—These methods are discussed under the following items: scope, preparation of materials, sampling for preliminary tests, cement tests, fine aggregate tests, coarse aggregate tests, mixed aggregate tests, proportioning, size of test pieces, mixing concrete, workability, forms, molding test pieces, capping cylinders, curing test pieces, age at test, sequence of tests, method of testing, application of load, record of tests, weight of concrete, density and yield, report of tests. R. M. K.

Standard specifications for gypsum partition tile block. A. S. T. M., *Yearbook*, **1925,** Serial designation: C 52–25, 32–34.—Specifications are discussed under the following headings: uses, composition, form and size, core spaces, dimensions, strength, absorption, fire resistance, sampling, marking, inspection, rejection and reheating. Under "Method of Testing" the following tests are described: compressive strength of gypsum partition tile or block, transverse strength of gypsum partition tile or block, and absorption for gypsum partition tile or block. R. M. K.

Standard specifications for gypsum plaster board. A. S. T. M., *Yearbook*, **1925,** Serial designation: C 37–25, 29–31.—Specifications are made under the following captions: compn., thickness, dimensions, weight, strength, finish, sampling, packing and marking, inspection, rejection and method of testing. R. M. K.

Standard specifications for gypsum wall board. A. S. T. M., *Yearbook*, **1925,** Serial designation: C 36–25, 26–28.—Specifications are made for the following items: compn., thickness, dimensions, weight, strength, finish, sampling, packing and marking, inspection, rejection and methods of testing. R. M. K.

Standard specifications for gypsum. A. S. T. M., *Yearbook*, **1925,** Serial designation: C 22–25, 22–24.—The tests are classified under the following divisions: (1) materials and standards, (2) sampling, (3) packing and marking, (4) inspection and rejection. These specifications were proposed as tentative in 1919 and adopted in amended form 1925. R. M. K.

Standard specifications for quicklime and hydrated lime for use in the cooking of rags for the manufacture of paper. A. S. T. M., *Yearbook*, **1925,** Serial designation: C 45–25, 20–21.—The specifications are given in three divisions: (1) requirements, (2) methods of test, (3) sampling, inspection and rejection. R. M. K.

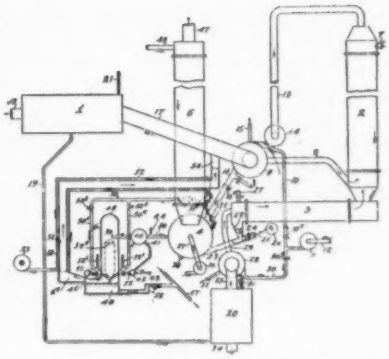
Factors affecting the time of set of mechanically-mixed gypsum mortars. L. E. SMITH. *Rock Products*, **28** [17], 61(1925).—The time of stirring of retarded gypsum mortars has no appreciable effect on their time of set. The addition of set gypsum accelerates the time of set of retarded gypsum mortars, the relative rate of set being approx. directly proportional to the amt. of set of gypsum added. (*C. A.*)

PATENTS

Process of making cement. EDWIN C. ECKEL. U. S. 1,555,405, Sept. 29, 1925. The process of making cement containing a titanium constituent, comprising the addition to a cement mixture, during or before fusion or clinkering, of a suitable proportion of an artificial titanic compound.

Process for the use of mixtures of aluminous cements with ordinary cements. SPERANZA SÉAILLES, NÉE CALOGÉROPOULOS AND JEAN SÉAILLES. U. S. 1,556,038, Oct. 6, 1925. A process for the use of aluminous cements in connection or in mixture with the ordinary hydraulic cements, which consists in placing in position a layer of aluminous cement and immediately afterward a layer of ordinary cement.

Process of making cement clinker. CHARLES B. HILLHOUSE. U. S. 1,555,283, Sept. 29, 1925. The process of making cement clinker with an iron or steel by-product, which consists in adding lime to iron sponge in less quantity than that required for clinker, fusing the sponge and lime to a liquid state in a fusion fur. at a temp. substantially lower than that for clinkering, withdrawing the resulting liquid slag from the fur., raising its temp. to that required for clinkering, and adding thereto, in a suitable chamber and at a clinkering temp., the lime necessary for cement clinker.



Dental filling material. PAUL W. KRUGER. U. S. 1,556,696, Oct. 13, 1925. A dental cement compn. consisting of a cement powder and a liquid in which guaiacol is the setting agent having setting reaction with said powder in forming a hardened mass. A dental cement comprising a powder suitable for dental uses, which comprises kaolin and magnesium oxide, and a liquid in which guaiacol is a setting agent that reacts with the powder to harden with it.

Hardening lime mortar or plaster. A. A. ALLES. U. S. 1,547,713, July 28, 1925. An intimate mixt. of finely divided coke and $CaCl_2$ is used as an addn. to lime. (*C. A.*)

Moldable oxychloride composition. J. A. RITCHIE. Brit. 229,092, Feb. 15, 1924. Mg oxide and chloride are used with fibrous material such as sawdust which is moistened before admixt. with the other ingredients. Powd. quartz, coke breeze and similar ingredients may also be added and Na silicate serves to facilitate obtainment of a smooth surface when the compn. is molded. (*C. A.*)

Dental cements. P. W. KRUGER. U. S. 1,548,616, Aug. 4, 1925. Deterioration of dental cement constituents, *e. g.*, those of oxychloride cements, is prevented by preserving them in admixture with volatile substances such as acetone, benzine or AmOH which are evapd. before the cement is used. (*C. A.*)

Enamel

Preliminary report of an investigation of the molding sand resources of Illinois. M. S. LITTLEFIELD. Ill. State Geol. Surv., *Rept. of Invest.*, **3**(1925).—A 37-page report. F. G. J.

Flotation of enamels. ANON. Bur. Stand., *News Bull.*, **101**, Sept., 1925.—A study of the factors governing the behavior of enamels suspended in water as used for coating metal shapes. F. G. J.

Why enamel products costs are low. KARL TURK. *Ceram. Ind.*, **4** [6], 453 (1925).—A description of the advances in the art of enameling that have reduced costs. F. G. J.

Enamel plant built on 30 years' experience has flood of new ideas. ANON. *Ceram. Ind.*, **5** [3], 228(1925).—An illustrated description of the new plant of the Ironton (Ohio) Stove and Mfg. Co. F. G. J.

Pyrometers abused in enamel plants. ANON. *Ceram. Ind.*, **5** [3], 233(1925).—What to do and what not to do. F. G. J.

Principles of enameling. VIII. Ground coat enamels for dry process enameling of cast iron. HOMER F. STALEY. *The Ceramist*, **6** [1], 384–95(1925).—Very little is known about the fundamental principles of compounding and prepg. ground coat

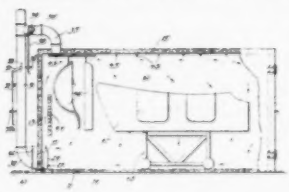
enamels. S. states requirements of a good ground coat enamel of the glassy type. S. compares several ground coat enamels that have been used successfully for long periods of time and calculates their "refrac. value." The refrac. value of a ground is supposed to indicate the general behavior of the ground when heated. S. discusses the percentage of raw additions and the relation of gloss to strength of bond. S. also points out further problems for research. (See following abstract.) A. E. R. W.

Principles of enameling. IX. Cleaning of iron and steel. HOMER F. STALEY. *The Ceramist*, **6** [4], 554–60(1925).—The more important subs. to be removed from iron and steel to be used in enameling are (1) oils and greases, (2) oxides or scale. The removal of oils is called "cleaning." The use of solvents produces a remarkably clean ware. Because of their expense, evaporation losses, fire hazard and injurious vapors solvents should only be used for removing non-saponifiable oils. Saponifiable oils should be removed by alk. solns. In prepg. solns. the chem. that can be used are, in the order of their efficiency, caustic soda, trisodium phosphate, soda ash, sodium silicate and borax. Hard water should be avoided. With saponifiable oils the cleaning action depends on emulsification and subsequent saponification. The soap formed also exercises a cleaning action. With non-saponifiable oils the cleansing by alk. solns. depends on emulsification and subsequent gravity sepn. The stability of the emulsion can be increased by (1) increasing alkalinity, (2) using more soln., (3) adding small amts. of soap. Too much stability makes the subsequent gravity sepn. difficult. The addition of solid particles of colloidal size and agitation also increases stability. In electrolytic cleaning the main cleaning action results from the production of finely divided gases. Cutting and drawing oils should be so chosen as to contain just sufficient saponifiable oils to give a stable emulsion during cleaning. S. gives formulas for cleaning solns. A 3rd method of cleaning is by htg. or "burning off." This also helps to remove strains. S. gives the particulars of good operation. See *Ceram. Abs.*, **4** [3], 59–61(1925) for previous articles in this series. A. E. R. W.

Status of sand tests. I. H. RIES. *Foundry*, **53**, 531–4(1925).—The usual tests applied to sand are discussed and the importance of standardization of tests pointed out. Sieve tests are more rapid than elutriation tests. After sepn. into groups of grain size the best manner of expressing the results is important. Four plotting methods are shown. (*C. A.*)

PATENTS

Enameling oven. JOHN A. MILLER. U. S. 1,555,304, Sept. 29, 1925. In a heat treating device of the class described, a chamber having an entrance leading thereinto, and a closure for said entrance, heating means located within said chamber, an air intake device located within said chamber in direct communication with the exterior atmosphere through an opening provided in the wall of said chamber and discharging directly into the interior of said chamber adjacent the lower portion thereof, said chamber being provided in one of its walls adjacent the lower end thereof with a ventilating opening communicating with said air intake device, and a ventilating conduit communicating with said opening and extending upwardly therefrom.



Glass

Forced draft gas generation. W. FRIEDMAN. *Glastechnische Ber.*, **3** [1], 8(1925).—In contrast to the steel indus. there are still in many glass works the old Siemans-Schütt generators with natural gas. Their advantages and disadvantages are discussed and compared with several types of forced draft generators. These are shown in drawings. Tables of relative efficiencies are given. F. G. J.

The microscopic structure of the surface of ground glasses. KARL HESSE. *Glastechnische Ber.*, **3** [2], 33(1925).—Fourteen photomicrographs of glass surfaces attacked by different agents. F. G. J.

The flame in the glass-melting furnace. K. HESSE AND W. FRIEDMAN. *Glastechnische Ber.*, **3** [2], 46(1925).—A long and thorough article on combustion as applied to the making of glass. The effects of excess air and of excess gas are studied. F. G. J.

Glasses as supercooled liquids. G. TAMMAN. *Glastechnische Ber.*, **3** [3], 73 (1925).—A long discussion of crystn., the relation of viscosity to the degree of supercooling, stability of glasses, etc. F. G. J.

Completely automatic glass blowing. WENDLER. *Glastechnische Ber.*, **3** [3], 87(1925).—Traces the history of automatic blowing from Atterbury in Pittsburgh in 1873 to modern times. The various advances are described and drawings are shown. F. G. J.

Investigation on the elasticity and breaking strength of glass as a building material. OTTO GRAF. *Glastechnische Ber.*, **3** [5], 153(1925).—The results of thirty years of testing building glass as well as recent work on test pieces of table glass. Results give the effect of load tests, impact tests and chem. anal. on many samples of 6 varieties of glass. There are numerous illus. on the methods of failure under test. F. G. J.

Measuring high gas temperatures by means of proper measurements of the oven elements. FOX MAULE. *Glastechnische Ber.*, **3** [4], 114(1925).—Discussion and mathematics of pyrometric lag. F. G. J.

Suggestions for better glass tank service. T. B. HART. *Ceram. Ind.*, **4** [6], 450 (1925). **Suggestion for regenerator improvement.** T. B. HART. *Ceram. Ind.*, **5** [2], 125(1925).—The drawing shown is a regenerative system that is in design recuperative. F. G. J.

Seven million dollar plant to have 15,000,000 sq. ft. annual plate glass output. ANON. *Ceram. Ind.*, **5** [1], 41(1925).—An illustrated description of the new Ottawa (Ill.) plant of the National Plate Glass Co. F. G. J.

Rapid test for purity of glass sand. ANON. *Ceram. Ind.*, **5** [2], 133(1925).—Describes a rapid approx. detn. of iron oxide in sand and a complete plant anal. of sand. F. G. J.

A good glass annealing schedule. ANON. *Ceram. Ind.*, **5** [3], 220(1925).—This article tells of the successful schedules used at the Gill Glass Co. F. G. J.

Chemical relations of glass, glazes and enamels. IV. ED. ZSCHIMMER. *Ceram. Ind.*, **5** [3], 225(1925).—A study of various typical glasses and a table of percentage compns. of 13 characteristic glasses. For parts I, II and III of this subject see *These Abs.*, p. 337. F. G. J.

A plant analysis for lime. ANON. *Ceram. Ind.*, **5** [3], 227(1925).—This article tells what anal. should be made for control work and how to make them. F. G. J.

Researches carried out at the Russian State Physico-Chemical and Rontgenological Institute. N. I. SIELAKOV. *Rev. Metal.*, **21**, 527–8(1924).—No indications of crystal structure were found in careful X-ray investigation of glass. In investigating clays it was found that highly plastic clays showed a fine crys. structure (diam. 6×10^{-7} cm.) while less plastic clays were much coarser. In clays excess silica increases the dispersion of the crystal system. W. M. C.

Principles of glass making. R. R. SHIVELY. *The Ceramist*, **6** [1], 396–9(1925).—S. reviews the reliable work that has been done on the effect of different chem. on the phys. properties of glass including (1) thermal expansion, (2) density, (3) elasticity, (4) tensile strength, (5) thermal condy., (6) crushing strength, (7) viscosity. See also *Ceram. Abs.*, **4** [3], 62–3(1925). A. E. R. W.

Washed pot clay for tank blocks. J. L. CRAWFORD. *The Ceramist,* **6** [3], 499–504(1925).—C. describes the mining, weathering and washing of Cheltenham clay and cites the advantages of using washed clay for tank blocks. A. E. R. W.

The influence of boric oxide in chemical glass. W. E. S. TURNER. *Pottery Gaz. and Glass Trade Rev.,* **50** [579], 1391(1925).—Tests with simple glasses showed that boric oxide has its limitations. It was then substituted for silica step by step in Kavalier glass. Between 11% and 13% boric oxide decreased the soly. of glass. Within limits it also reduces the thermal expansion. F. G. J.

Construction of glass pots in North America. H. SCHNURPFEIL. *Feuerfest,* **1** [5], 46(1925).—Difference between European and Amer. practice shown. The latter are made thinner and lighter and have longer life. German clays such as Gross Almerode, Meissen and Vallendar used for bond and Amer. clays in form of grog. Importance of proper tempering stressed. F. A. W.

Structure of glass. N. SELJAKOV, L. STRUTINSKI AND A. KRASNIKOV. *Z. Physik,* **33,** 53–62(1925); *Jour. Soc. Chem. Ind.,* **44B,** 716(1925).—The refractive index and coeff. of expansion of glass show a max. near 575°, which is the transition temp. of α-quartz to β-quartz. X-ray analysis, however, shows no signs of quartz crystals, and it is concluded that the change at this temp. is a change in the molecule of the glass, and that glass can truly be looked on as a supercooled amorphous fluid. The structure of α-cristobalite is worked out from X-ray data, and that of β-cristobalite is suggested. H. H. S.

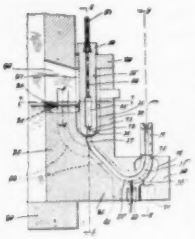
Adsorption of water from the gas phase on plane surfaces of glass and platinum. I. R. MCHAFFIE AND S. LENHER. *J. Chem. Soc.,* **127,** 1559–72(1925); *J. Soc. Chem. Ind.,* **44B,** 716(1925).—Adsorption of water and its accompanying free energy change are much greater on glass than on Pt. The thickness of the adsorbed film varies from 0 to 39 molec. layers with different temps. and pressures. H. H. S.

Flint glass industry. ANON. *Jour. Soc. Chem. Ind.,* **44B,** 850(1925).—The British flint glass industry's application for Govt. aid under the Safeguarding of Industries Act has been refused, though it is hoped only temporarily. H. H. S.

Quartz filters. ANON. *Chem.-Zeit.,* Aug. 25, p. 716(1925); *Nature,* **116,** 516 (1925).—Experimental tests on quartz crucibles with filtering bottoms have been made by the Jena firm of Schott und Gen. The porous bottoms are made from the same mat. as the crucibles themselves, and in the case of those made from rock crystal the analytical results were highly satisfactory, even when normal solns. of ammonia or caustic alkalies were used for washing ppts. The speed of filtration is rather slower than with ordinary asbestos pads in the Gooch crucibles. The analytical results obtained with the opaque crucibles were not quite so good, but the latter are suitable for filtering very hot liquids. O. P. R. O.

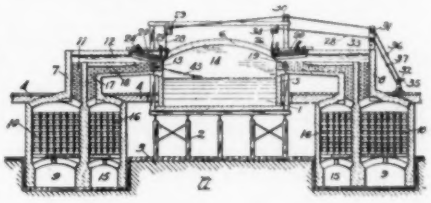
Uniform temperature maintained in glass tank with Amco recuperator. C. B. MCCOMAS. *Fuels and Fur.,* **3** [9], 1053–4(1925).—The construction and operation of the recuperator is described. R. M. K.

PATENTS

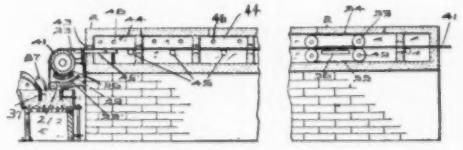


Glass mold-filling apparatus. WILLIAM G. BERGMAN. U. S. 1,554,195, Sept. 22, 1925. In a glass mold filling app., a chambered body engaged with the fur., a nozzle adapted to discharge melted glass into a mold, an internal conduit formed in said body between said fur. and said nozzle, means for draining said conduit comprising a removable plug located at the base of said conduit, an injector in said body, and means operatively combined with said injector for exhausting or compressing the air therewithin.

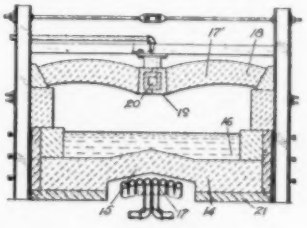
Glass-melting furnace. BJARNE H. SCHIELDROP. U. S. 1,554,251, Sept. 22, 1925. In a glass melting fur. an enclosed passage for conducting heated air to the fur., gas feeding means projecting into the passage near its entrance to the furnace, said means comprising a pair of nozzles positioned one above the other so that the two streams of gas will be directed into the fur. along converging lines in the same vertical plane, and means for independently swinging the nozzles in a vertical plane to vary the point of contact of the two flames, or to vary the inclination of the resulting fan-shaped flame with respect to the surface of the molten glass.



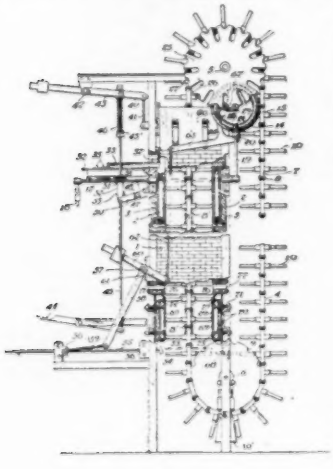
Drawing sheet glass. ROBERT G. EWING. U. S. 1,554,267, Sept. 22, 1925. In combination with app. for drawing a sheet of glass from a mass of molten glass, a smooth surfaced cylindrical cooling roller substantially as long as the sheet width and positioned in contact with one face of the sheet near its source. In the drawing of sheet glass, a hollow fluid-containing porous bending roller. In a sheet glass drawing app. a temp. affected roll for extending transversely of a sheet of glass, said roll having internal radiation surface increasing inwardly of the sheet from an edge of the sheet of glass.



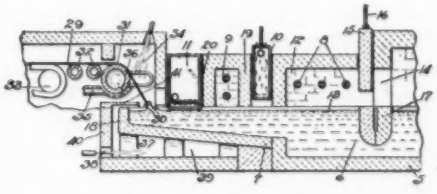
Cooler-chamber construction. ENOCH T. FERNGREN. U. S. 1,554,268, Sept. 22, 1925. In sheet glass app., including a cooling chamber, means for continuously passing a stream of molten glass therethrough, means for retarding the flow of the central portion of the stream, and means for increasing the column of heat above the border portion of said steam of glass.



Leer. ROBERT GOOD. U. S. 1,554,275, Sept. 22, 1925. In a vertical leer for annealing glassware, an endless conveyor having one run thereof adapted to move downwardly through the leer, a plurality of leer pans carried by the conveyor and means coöperating with the leer pans for sealing one end of the leer.



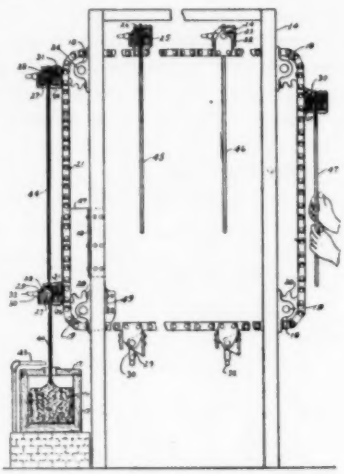
Sheet-glass apparatus. ENOCH T. FERNGREN. U. S. 1,554,269, Sept. 22, 1925. The process of producing sheet glass, consisting in alternately heating and cooling the surface of a mass of molten



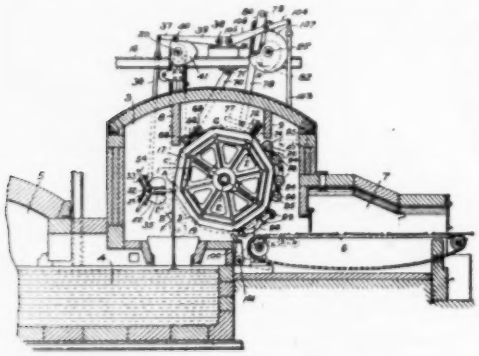
glass to create a floating unit of plastic glass on a body of molten glass and then drawing the floating unit off in sheet form.

Process of molding bottles. JOHN RAU. U. S. 1,554,464, Sept. 22, 1925. The process of forming a bottle or the like of glass, consisting of blowing a blank having a neck with a head thereon of the usual character and forming at opposite end of said blank an enlarged portion extending laterally beyond the walls of the blank.

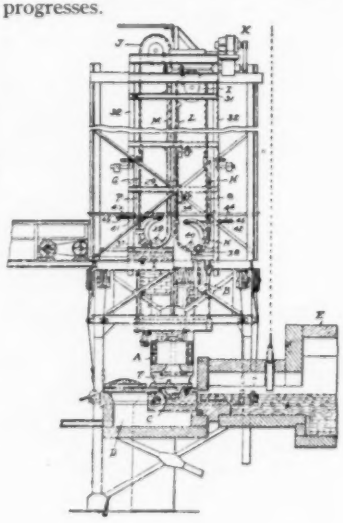
Continuous-glass-drawing device. HECTOR BAZIN and ARSENE BAYLE. U. S. 1,554,547, Sept. 22, 1925. A glass sheet drawing mach., provided with endless carriers, a frame for supporting the said endless carriers, bearing brackets suitably attached to the said endless carriers, a glass sheet clamping device adapted to swivel in the said bearing brackets and blocks attached to the said frame, the said blocks contacting with and guiding the said glass sheet clamping device to a position adjacent the glass sheet without deflecting the said glass sheet from its drawing position.



Process and apparatus for drawing glass. HERMAN S. HEICHERT. U. S. 1,554,848, Sept. 22, 1925. In combination in a glass drawing app., a receptacle for a glass bath, a drawing drum located over the bath and provided intermediate its corners with flattening plates, and a heating element for engaging the glass sheet which is drawn along the line at which the glass is bent preliminary to its engagement with the corners of the drum and for continuing such engagement as the bending progresses.

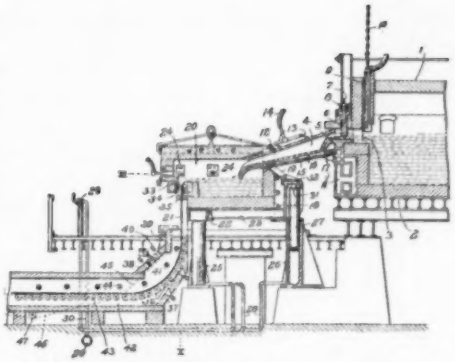


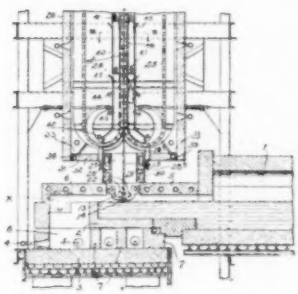
Apparatus for drawing sheet glass. HALBERT K. HITCHCOCK. U. S. 1,554,850, Sept. 22, 1925. A drawing device for sheet glass comprising a pair of opposing endless belts for gripping the sheet therebetween and means for driving the belts, one of the said belts being provided at intervals with transverse slots to permit the cutting of the glass while passing along between the belts.



Process and apparatus for making sheet glass. HALBERT K. HITCHCOCK. U. S. 1,554,851,

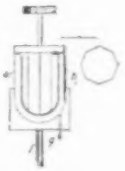
Sept. 22, 1925. In combination in app. for forming sheet glass, a melting tank, a secondary tank in position to receive a gravity flow of molten glass from the melting tank, mounted for vertical movement and provided with a discharge slot directed downwardly, means below the slot for receiving and turning laterally the ribbon of glass discharged through the slot and a horizontal leer in position to receive the ribbon from said means and provided with means for carrying it therethrough.

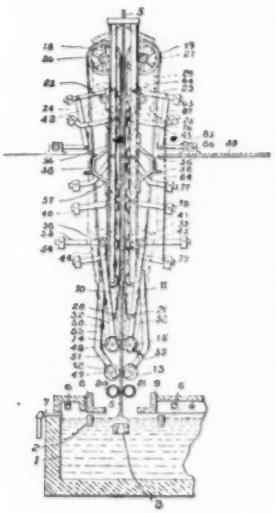




Apparatus for making sheet glass. HALBERT K. HITCHCOCK. U. S. 1,554,852, Sept. 22, 1925. App. for drawing sheet glass, comprising a tank extension carrying a bath of molten glass and having a cover provided with a transverse opening, a slot member mounted in said opening, means for supporting said slot member so that it may be moved vertically above the cover portion and then longitudinally of the extension drawing and annealing mechanism located above the slot member and a drawing chamber between said drawing mechanism and slot member mounted for movement laterally to provide clearance for the positioning and removal of the slot member.

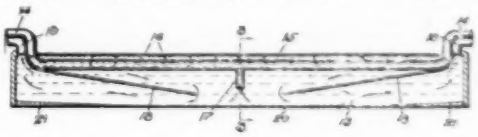
Method for the production of double-walled glass vessels. WILHELM HODECKER. U. S. 1,554,853, Sept. 22, 1925. A method for producing double walled glass vessels, vacuum flasks and the like, by blowing in a mold a hollow glass body to the shape of the finished outer walls of the vessel including the complete doubled rim of the vessel and providing a dome portion thereon which subsequently forms the inner walls of the vessel.



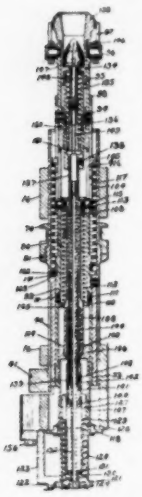


Process of drawing sheet glass. HARRY G. SLINGLUFF. U. S. 1,554,886, Sept. 22, 1925. A process of producing sheet glass continuously from a glass bath which consists in applying rotating frictional drawing means to the sides of the sheet above the surface of the bath sufficient to continuously draw the sheet, chilling the glass by radiation, below said means, so that the sheet is below its temp. of setting when it reaches said drawing means and applying a heat insulation against the sides of the sheet above the drawing means and continuing said insulation until the glass cools sufficiently to be cracked off.

Cooler for sheet-glass apparatus. ENOCH T. FERNGREN. U. S. 1,554,994, Sept. 29, 1925. In sheet glass

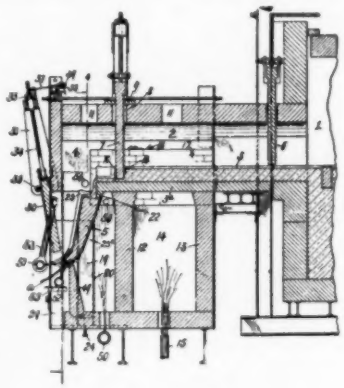


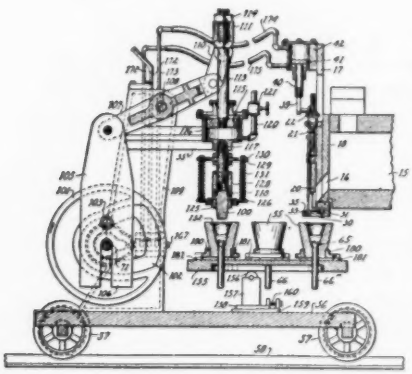
app., means for drawing a sheet of glass from a mass of molten glass, of means for lowering the temp. of the surface glass thereof before it is drawn into the sheet, including means for introducing a cooling medium in proximity to and centrally of the said glass and allowing the cooling medium to pass from the center toward both sides of said mass of molten glass.



Glass-blowing-spindle apparatus. AUGUST KADOW, ALVAH C. PARKER and CARL W. SCHREIBER. U. S. 1,555,216, Sept. 29, 1925. In combination, a glass carrying spindle journaled in two bearings, jaws for clamping a blank upon the spindle, and jaw closing means mounted to move inside of one of said bearings.

Method and apparatus for making sheet glass. EDWARD DANNER. U. S. 1,555,358, Sept. 29, 1925. The method of forming sheet glass, consisting in causing molten glass to flow in laterally divided form around and down a directing part in a tempering heat and in merged single sheet form therefrom. In an app. for forming sheet glass, means forming a molten glass supply and having a discharge outlet in its bottom portion, means coöperating with said outlet to partially close the same and to cause glass to flow therefrom in laterally divided streams which merge and flow in single sheet form from the lower end thereof, said second means being adjustable relative to the first means to regulate the size of the opening and the consequent thickness of the glass streams flowing therefrom, and means for controlling the temp. of the glass flowing down said second means.

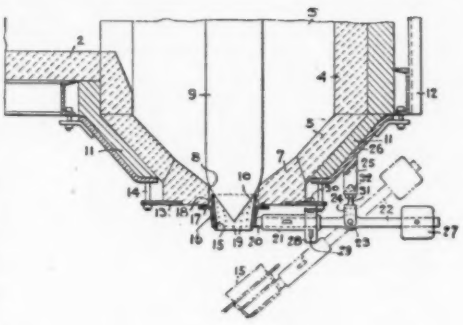




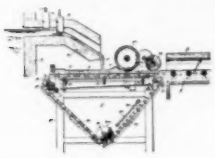
Glass-molding machine. SAMUEL ESTE WINDER and HENRY COTTON DAUBENSPECK. U. S. 1,555,897, Oct. 6, 1925. In a glass working mach. the combination with a mold, of a pressure plunger adapted to coöperate with said mold, reciprocating means, means comprising a cylinder and piston connection operatively connecting said reciprocating means and said plunger, means for supplying fluid pressure between the cylinder and piston and adjustable means in said fluid pressure supplying means for checking back flow from said cylinder, whereby an adjustable pressure greater than the supp'y pressure may be intermittently built up.

Insulating cement or mortar. LYLE CALDWELL. U. S. 1,556,488, Oct. 6, 1925. An insulating cement or mortar composition consisting principally of powdered diatomaceous earth and an organic adhesive and containing not over 7% of a salt adapted to act as a distending agent with respect to said organic adhesive.

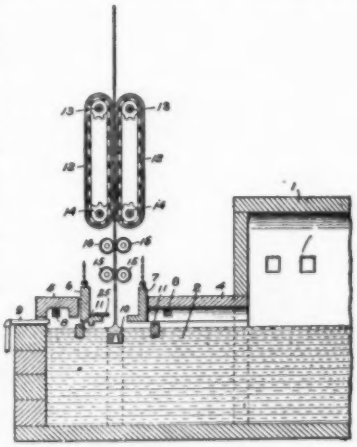
Method and apparatus for casting plate glass. FRANK E. TROUTMAN and CHARLES H. CHRISTIE. U. S. 1,556,381, Oct. 6, 1925. The method of casting plate glass that comprises flowing the glass through a downwardly opening outlet in a receptacle, checking the descent of the sides of the issuing glass and causing a portion of said glass to form a discharge throat, and discharging another portion of glass through said glass-lined discharge throat upon a casting table.



Art of producing continuous sheet glass. CLARENCE W. AVERY and EDWARD T. BROWN, U. S. 1,556,665, Oct. 13, 1925. In the art of producing continuous sheet glass, the method of forming the sheet which consists in establishing an unconfined pool of the molten metal on a flat traveling surface in advance of and leading to a forming pass with the pass dimensions substantially equal to the thickness of the sheet and greater than the width of the sheet and continually passing metal from the pool through the pass to form the sheet, whereby the unconfined characteristic of the pool will be maintained within the pass with respect to the sheet edges, the pool characteristic being maintained by a continuous supply of metal thereto, the width of the sheet being produced by the natural flow of metal within the pool.

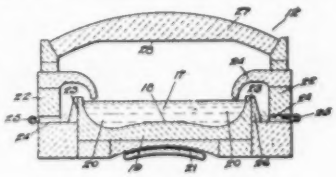


Glass-drawing apparatus. HARRY G. SLINGLUFF. U. S. 1,556,726, Oct. 13, 1925. In combination in app. for drawing sheet glass, a glass drawing tank adapted to carry a bath of molten glass, at a particular level, means for drawing a sheet upward from the bath and a refrac. bar in the bath and extending transversely across the tank below said level of the bath and the line of generation of the sheet, said bar having its upper portion of varying width, widest at the center portion and decreasing in width toward the end portion.

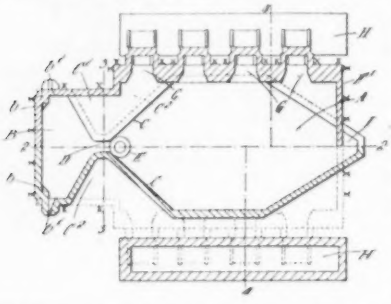


Metallic mold for forming glass articles and method of making same. FRED JAMES FRINK AND ROBERT LEONARDSON FRINK. U. S. 1,556,925, Oct. 13, 1925. A mold for forming articles from molten glass, said mold being made of a metallic alloy and having its inner surface of a vascular or finely pitted character.

Sheet-glass apparatus. ENOCH T. FERNGREN. U. S. 1,557,148, Oct. 13, 1925. In sheet glass apparatus, including a draw-pot containing a source of molten glass, of means for directing heat along the border portions of the molten glass within said pot.



Glass-melting furnace. THOMAS COURTNEY MOORSHEAD. U. S. 1,557,078, Oct. 13, 1925. A glass melting tank fur. comprising a melting compartment, a working compartment, a bridge wall separating said melting compartment from said working compartment, the sides of said bridge wall being so disposed relatively to both the working and melting compartments as to avoid right angled corners in which dormant glass can collect and the other boundary walls of said melting compartments being also so formed as to avoid right angled corners.



Apparatus for molding glass. ALFRED P. VOLLMAR. U. S. 1,557,504, Oct. 13, 1925. A machine for molding glass comprising a table mounted for horizontal rectilinear movement adapted to receive a layer of soft or plastic glass as it is moved horizontally, said table having a plurality of spaced apertures, a vertically movable die mounted in each of said apertures, a vertically movable table carrying die members adapted to move downwardly into engagement with the upper surface of the layer of glass on the horizontal table when said horizontal table is positioned under said vertically movable table with the dies in the upper and lower tables in coöperating relationship and means for withdrawing the upper tables and dies and lowering the lower set of dies and permit the molded glass to rest on said horizontally movable table free from the die members.

Process of manufacturing resistant glass. VÁCLAV HORÁK. U. S. 1,557,540, Oct. 13, 1920. The method of manufacturing a resistant glass, which will support a sudden fall of temp. from 320° to 0°C consisting in melting at about 1200°C a mixture of sand, boric acid, potassium carbonate, sodium carbonate, kaolin, muscovite, zirconic oxide and titanic oxide.

Glass composition. W. C. TAYLOR. Can. 248,316, Mar. 31, 1925. A low-expansion glass contains over 70% SiO_2, B_2O_3 10–15, Al_2O_3 1–5, Na_2O less than 6, LiO 0–2, and ZrO 0–6%. (*C. A.*)

Frosting glass. M. PIPKIN. Brit. 228,907, Feb. 4, 1924. NH, bifluoride or an alkali metal bifluoride is used subsequent to the usual treatment for frosting the inside of elec. lamp bulbs or other glass articles. This treatment is stated to strengthen the walls of lamp bulbs. (*C. A.*)

Heavy Clay Products

Brickmaking and the use of brick in Sweden. II. G. WSON CRONQUIST. *The Clay Worker*, **83** [6], 53(1925). (For Part I see *Ceram. Abs.*, **4** [7], 193(1925).)—Continuous kilns are used almost entirely in Sweden and there is not a single round downdraft kiln there. Continuous tunnel kilns are standard in sizes with output of 6000 to 30,000 bricks daily. Fired to 1000°C it needs 5% coal to weight of fired brick. The firings are even and the kiln is economical to set and empty. There is much coal with 50% ash and some shale containing coal. This is fired in great charring stacks to make grog. The ashes from the gas producers are also used for grog.

F. G. J.

Saving fuel in brick manufacture. W. D. RICHARDSON. *The Clay Worker*, **84** [1], 26(1925).—Calls attention to Cronquist's article and expands on 2 of his points: the general use of continuous tunnel kilns and of cheap coal in gas producers. Points a moral to American brickmakers. F. G. J.

Brick. D. KNICKERBAKER BOYD. *The Clay Worker*, **84** [1], 22(1925).—A long paper presented at the annual meeting of the A. S. T. M. discussing the methods of

testing brick. B. advocates stressing the tests on walls and piers rather than on individual brick. Different tests are discussed separately and modifications are suggested. F. G. J.

Advantages and disadvantages of the tunnel kiln. II. ANON. *The Clay Worker*, **83** [6], 526(1925). (For Pt. I see *Ceram. Abs.*, **4** [7], 199(1925).)—A description by Walter Pohl of two successful attempts to make brick in tunnel kilns designed for other purposes. In one case full details of coal consumption and output are given. *Ibid.*, **III.** ANON. *The Clay Worker*, **83** [7], 629(1925).—An anonymous criticism of the above stating that the efficiency shown was less than that of a ringofen. *Ibid.*, **IV.** ANON. *The Clay Worker*, **84** [1], 28(1925).—A description by Bernhard Ultsch of a tunnel kiln, style Lengersdorf, with pressure gas htg. and a length of 92 m. for the firing of brick and roofing tile. A temp. of 1688°F (cone 09a) is attained. For a daily production of 12,000 bricks, Austrian standard, weighing 57,000 kg., 2400 kg. of brown coal is required, 4.2%. With hard coal, it is estd. that 2.9% would be needed. F. G. J.

Face brick in "Home Town" movie. ANON. *Brick and Clay Rec.*, **66** [9], 663 (1925).—The Amer. Face Brick Assn. with 19 other nationally known firms and associations is sponsoring a movement to "Boost your town-trade at home." Face brick comes in for a good measure of attention in the campaign. F. G. J.

Humidity driers for sewer pipe. ANON. *Brick and Clay Rec.*, **66** [9], 668(1925).—Discussion on the suitability of the humidity drier to replace the huge drying floors of the sewer pipe industry. Each side of the question is presented by an authority in the manuf. of clay products. F. G. J.

Asks for contributing factors to bad case of tile lamination. ANON. *Brick and Clay Rec.*, **66** [10], 750(1925).—Several interesting answers are given by responsible clay products mfrs. F. G. J.

Thirty-three per cent more pipe with same equipment. ANON. *Brick and Clay Rec.*, **66** [9], 675(1925).—A discussion of the merits of piecework over day rate of pay. F. G. J.

The problem of shading. J. G. SEANOR. *Brick and Clay Rec.*, **66** [10], 758 (1925).—How it can be made easier. Helping the men to produce better results. Should you suit the salesman's pleasure or the superintendent's convenience? F. G. J.

Better colors for clay products. D. A. MOULTON. *Brick and Clay Rec.*, **66** [11], 824(1925).—Methods to secure a better red are briefly given. F. G. J.

Better colors for clay products. P. E. COX. *Brick and Clay Rec.*, **66** [11], 824(1925).—The column of clay may be sprayed with glaze from a battery of spray guns. F. G. J.

The tractor's place in clay winning. H. L. AUSTIN. *Brick and Clay Rec.*, **66** [11], 828(1925).—How one plant is successfully using tractors and scrapers in its clay pit. F. G. J.

Making common brick on a wholesale scale. ANON. *Brick and Clay Rec.*, **66** [12], 900(1925).—Third plant of the Lake View Brick Co. opened. It uses waste heat driers and lime instead of grog. F. G. J.

Making 100,000 brick with 44 men. ANON. *Brick and Clay Rec.*, **66** [13], 973 (1925).—The plant of Camp Brothers Co., Mogadore, Ohio is described. It has many labor saving devices. F. G. J.

Why do preliminary crushing? ANON. *Brick and Clay Rec.*, **66** [13], 983(1925).—A discussion of the advantages of prepg. hard clays and shales before giving them to the dry pan. This saves time, men, money and gives you a better product. F. G. J.

When it pays to replace machinery. B. A. FRANKLIN. *Brick and Clay Rec.*, **66** [13], 987(1925).—Machine equipment must do more than lower the price and raise the quality of its output over the hand labor which it replaces. It must match or excel the output of competitors' machines. Worn out and obsolete equipment carries insidious dangers. A formula is given to tell when to replace any machine.

F. G. J.

Brick and tile in building codes. ANON. *Brick and Clay Rec.*, **67** [1], 30(1925).—Complete excerpts are given from the report of Secy. Hoover's Building Code Committee on Recommended Minimum Requirements for Masonry Wall Construction. This rept. will be used throughout the country in revising antiquated bldg. codes and drafting new ones. F. G. J.

Grinding 1500 tons of shale daily. ANON. *Brick and Clay Rec.*, **67** [1], 38 (1925).—A description of the grinding process of the Metropolitan Paving Brick Co. at Bessemer, Pa. F. G. J.

Care and operation of a dry pan. A. F. GREAVES-WALKER. *Brick and Clay Rec.*, **67** [1], 40(1925). F. G. J.

Manufacturing "Summitville reds." ANON. *Brick and Clay Rec.*, **67** [2], 111 (1925).—An account of the Summitville (Ohio) Clay Products Co. F. G. J.

Model building code attacked. ANON. *Brick and Clay Rec.*, **67** [3], 179(1925).—Claims of unfairness and partiality are made and apparently substantiated against the report of the building code committee of the U. S. Dept. of Commerce. Some of the sections are detrimental to brick. F. G. J.

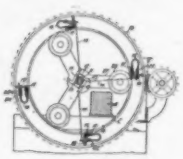
The editor builds his third plant. ANON. *Brick and Clay Rec.*, **67** [4], 252 (1925).—A description of the new plant of the Alliance Brick Co., at Darlington, Pa., making face brick. F. G. J.

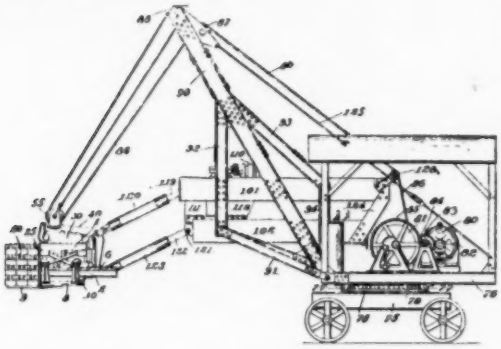
Brick laying machine. ANON. *Contract Rec. and Eng. Rev.*, **39**, 975(1925).—A machine for laying brick is said to have been perfected, called the "K" erector, made by Wm. Arrol of Glasgow where it is being used. It consists of tubular uprights, connected at top and bottom, and free to travel on rails laid along the outside walls. Across the width of the house to be built, and carried on the uprights, is a boom which can be raised and lowered. On it are mounted a small traveling carriage, the mortar tank and the bricklaying mechanism. With the last named over the starting point the laying wheel rotates, taking 2 bricks at a time from the hopper, while the measg. mortar wheel spreads the mortar. Thus, as the carriage moves across the boom, one row of brick is laid. When the end of the wall is reached the direction of the carriage can be changed and the movement of the machine adjusted so as to lay brick along one of the side walls, and then across the back and up the other wall to the point where the work was started. After a course has been laid all around, the boom has to be raised by the thickness of one brick, plus the mortar joint and the operation repeated until the desired height is reached. Provision is made for automatically cutting off the supply of brick and mortar whenever a doorway or window intervenes. The feeding of the brick into the hopper is best performed by hand and the speed at which the machine lays the brick is regulated thereby. The average is said to be between 1200 and 1500 bricks per hr. O. P. R. O.

PATENTS

Silica-lime brick and method of producing the same. CARL MENDIUS. U. S. 1,554,639, Sept. 22, 1925. The process of making a brick which consists in mixing with virgin granulated blast fur. slag a small quantity of lime and a small quantity of a hard crushed material high in silica content, forming the mass in a moistened condition and under heavy pressure into the desired shape, and then curing the brick by subjecting it for several hours to steam at a high pressure.

Brick or block cutter. ALEXIS PRESTON STEELE. U. S. 1,555,769, Sept. 29, 1925. In a cutter of the class described employing a reel having cutter wires and bars disposed about the reel and provided with springs for tensioning the cutter wires: a block on that arm of each spring to which a wire is attached, the bars carrying the springs having slots affording clearance for the movement of an arm of each spring and said blocks each adapted to gravitationally assume a position at a slot of the angle bar or a position away from said slot so that in one position of each block said spring arm may have movement to the full extent of a slot and another position of the block the movement of the spring in said slot will be limited.





Brick-setting apparatus. GRAFTON E. LUCE. U. S. 1,555,785, Sept. 29, 1925. App. of the kind described comprising a brick setting device, a pivoted support carrying said device, a crane mounted, with provision for a full circle swing and connected to said support by flexible cables to raise or lower the support and brick setting device, in combination with automatic means to maintain the brick setter substantially horizontal within its range of movements.

Hollow-building-wall construction. FREDERICK HEATH. U. S. 1,556,333, Oct. 6, 1925. A building hollow wall construction, comprising hollow blocks throughout, arranged in courses and having even continuous horizontal mortar beds, each course having one or more three void blocks having side and intermediate load bearing webs, the intermediate webs being separated by a median longitudinal void, and each course including blocks having vertical voids with webs and shells spaced apart distances corresponding to the spacing of the webs and shells of the three void blocks, each block in the structure being preferably arranged in overlapping relations with blocks in courses above and below to provide a bonded structure, all of the load bearing webs and shells of the two forms of blocks throughout the entire wall construction including corners and pilasters lying in true vertical planes and forming continuous vertical compression members throughout the entire structure.

Refractories

Refractoriness of clays. H. SALMANG. *Archiv. für Wärmewirtschaft*, **6**, 241–2 (1925).—The factors affecting the value of clays for high temp. services are discussed. For testing refrac. clays, the softening point detn. is more reliable than chem. anal. but may be from 300° to 500°C above the max. safe temp. for service under load. E. E. P.

Flux block or fire brick for smelters? E. B. PRENTICE. *Ceram. Ind.*, **5** [3], 235 (1925).—Lack of standardized sizes prevents the use of blocks. Standard fire bricks should be used with very thin joints. F. G. J.

Refractories Institute defined. J. D. RAMSAY. *Brick and Clay Rec.*, **66** [9], 661(1925).—Central bureau to develop real research work and forum for consumer and producer problem discussion are its main objects. F. G. J.

Refractory classification and characteristics. H. W. Brooks. *Brick and Clay Rec.*, **66** [10], 763(1925). (Reprinted from *Power.*)—A classification of the well-known refractories and the principal considerations governing correct refrac. application. F. G. J.

Unusual processes in dry pressing fire brick. Anon. *Brick and Clay Rec.*, **66** [12], 904(1925).—Research and repeated plant experiments by the Niles (Ohio) Fire Brick Co. solved the problem of dry pressing fire brick. F. G. J.

They make no second grade ware. Anon. *Brick and Clay Rec.*, **67** [3], 191 (1925).—An account of the Massillon (Ohio) Stone and Fire Brick Co. F. G. J.

Preliminary findings in refractory investigations. I. Ralph A. Sherman, P. D. Helser, H. W. Brooks and G. A. Bole. *Power*, **62** [7], 234(1925).—The Bureau of Mines in coöperation with 18 companies has undertaken an investigation of problems connected with boiler-fur. refrac. Among the causes of refrac. failure studied are fusion, distortion under load, spalling, slag action, failure of support, thermal expansion and contraction, permanent vol. change and fur. wall construction. *Ibid.*, **II.** P. D. Helser and G. A. Bole. *Power*, **63** [8], 277(1925).—The 2nd part of this investigation deals with the raw mats. entering into and the methods of manuf of boiler-fur. refrac. Flint, plastic and siliceous fire clays are among the principal refrac. mats.; some of their phys. chem. and geological properties are given. Among the special refrac. materials studied are diaspore, bauxite, kaolin and silicon carbide. The method of manuf. and influence of properties on the ware forms an interesting part of this investigation. C. J. H.

Radiation in the pulverized-fuel furnace. Walter J. Wohlenberg and Donald G. Morrow. *Mech. Eng.*, **47** [8], 627(1925).—It is shown that the radiating power through the flame surface depends primarily on the size of the particle and that, based on the flame surface area, its magnitude is low. The heat absorption intensity at the cold surface, however, may be considerably higher than the relative radiance of the flame. This factor depends on both the amt. and disposition of the refrac. fur. lining. Curves are given supplementing the analytical process by which the method outlined may be applied. C. J. H.

Boiler furnaces for pulverized coal. A. G. Christie. *Mech. Eng.*, **47** [8], 632 (1925).—An anal. of the fund. of combustion of pulverized coal indicates that the following conditions are desirable for the highest efficiency and max. capacity of a given fur.: Coal should be finely ground, thoroughly dry and preheated. Primary and sec. air should be highly preheated. Turbulence should exist inside fur. The walls should be water cooled. Among the topics discussed are methods of heat transfer, nature of combustion, fur. walls, air preheaters, coal driers and ash. C. J. H.

Refractory materials for coking chambers and gas plants. L. Litinsky. *Feuerfest*, **1** [7], 65(1925).—Between the 2 extremes of silica (acid) and clay (basic) brick lies the group of intermediate brick contg. both quartz and fire clay grog. The expansion of the silica is neutralized by the shrinkage of the grog at high temps. resulting in a brick of stable vol. A general description of the origin and characteristics of the various raw mats. used follows. F. A. W.

The influence of oxidizing and reducing atmospheres on refractory materials. A. E. Vickers and L. S. Theobald. *Trans. Ceram. Soc.* (Eng.), **24,** 87–97(1924–25); *Ibid.*, **II. 24,** 98–104(1924–25); *Jour. Soc. Chem. Ind.*, **44B,** 716–7(1925).—Abstracted in *Ceram. Abs.*, **4** [11], 309(1925). H. F. S.

The relation between under-load refractoriness, ordinary refractoriness and composition, physical and chemical, of refractory materials. Pt. II. Firebricks. A. J. Dale. *Trans. Ceram. Soc.* (Eng.), **24** [2, 3], 170–98(1924–25). H. F. S.

An investigation of the effects of load, temperature and time on the deformation

of firebrick material at high temperatures. A. J. DALE. *Trans. Ceram. Soc.* (Eng.), **24,** 199–215(1924–25). Also *Jour. Soc. Chem. Ind.*, **44B,** 717(1925).—Abstracted, *Ceram. Abs.*, **4** [11], 310(1925). H. F. S.

Present state of knowledge of the resistance of smelting industry refractories toward changes in temperature. W. STEGER. *The Ceramist,* **6** [1], 374–84(1925).—The sensitiveness of a body to temp. changes depends on not only the chem. compn. but also the shape and physical structure of the body. S. discusses rapid methods of measg. a body's resist. to temp. change and also the formula of Winklemann and Schott for calcg. it from measurable phys. constants. The resist. to spalling of a fire brick depends on (1) structure, (2) porosity, (3) chem. compn., (4) firing temp. S. summarizes the results of 6 investigations of the temp. sensitivity of clay fire brick. The resist. of silica brick to temp. change is dependent upon the mineralogical character of the silica. S. agrees with Mellor that the sensitiveness of magnesite brick is due to (1) incomplete preliminary firing of the magnesia, (2) the large coeff. of expansion of magnesia. S. questions Mellor's demonstration of the existence of 2 forms of magnesia as Mellor's results can be attributed to the fact that the sp. gr. of amorphous magnesia depends on the firing temp. of the magnesite used in its production as shown by A. Ditte. A further cause of the sensitivity of magnesite brick is found in its high degree of sintering. A. E. R. W.

Present state of knowledge concerning the resistance of smelting industry refractories towards changes in temperature. W. STEGER. *The Ceramist,* **6** [2], 452–69 (1925).—While the behavior of magnesite and silica brick toward changes in temp. have been fully explained we have as yet no good explanation of the very different behavior of different fire clay brick. S. describes app. for measg. the coeff. of expansion of refrac. By measg. the expansion of a fire brick over 4 ranges of temp. the effects of quartz inversions can be shown. S. concludes from his measurements that the difference in resist. to thermal shock shown by different kinds of fire brick can be explained on the basis of the amt., size of grain and cryst. form of the SiO_2 modifications that may be present. A. E. R. W.

The temperature gradients obtained by different rates of heating in unfired fireclay bricks, between 15°C and 250°C. L. S. THEOBALD AND A. T. GREEN. *Trans. Ceram. Soc.* (Eng.), **24,** 105–23(1924–25).—The temp. gradients obtained by different rates of heating in unfired fire clay brick between 15° and 250°C have been investigated by a method which dets. the exterior and interior temps. of the unfired brick submitted to various rates of heating in a specially designed app. A consideration of the "gradient-ratio" curves shows that when the max. value of the ratio is obtained, the interior temp. of the brick lies between 117° and 121°C. This fact suggests that all the mech. and hygroscopic water has been expelled when this interior temp. has been reached. Also, it may be assumed that practically the whole of the water leaves the brick between the temps. of 100°C on the exterior and 120°C in the interior of the brick. The time required to establish these conditions varies with the temp. diffusivity of the mat., the amt. of water present and the rate of heating of the brick. It appears that the maintenance of an adequate constant temp. during the period of evolution of steam would be an effective method of preventing the production of large strains. From data obtained, the min. time required for the safe rate of heating the green brick to a temp. of 250°C has been considered for 3 types of brick investigated under the particular conditions described. H. F. S.

Observations on the elimination of carbonaceous matter from fireclay bricks. L. S. THEOBALD AND A. T. GREEN. *Trans. Ceram. Soc.* (Eng.), **24,** 159–69(1924–25).—The mat. used was Stourbridge fire clay as this seemed to show the elimination of the carbonaceous matter to the greatest advantage. Under the particular conditions of

the heat treatment, no change is apparent in the test specimen at temps. below 500°C, but at 600°C oxidation has, undoubtedly, commenced. With full-sized brick drawn from actual firings the cores become distinctly darker and blacker as the time at 600°C is increased, indicating that as htg. continues further changes are taking place in the carbonaceous matter in the center of the piece. As soon as the temp. approaches 650°C, a white ring, which develops into a yellow area, follows the removal of the carbonaceous matter. Above 600°C some chem. action takes place in a deficiency of air in the interior of the piece, which is manifested as a yellowish area replacing the carbon. On htg. to 750°C, there is a darkening in the shade of the interior as if a diffusion of carbon had taken place. Reduction of the iron to the ferrous state may also contribute to this change. The black cores at this temp. are definitely replaced by persistent yellow areas and a more prolonged soaking at 750°C would not remove them. H. F. S.

An investigation of the changes taking place during the industrial firing of fire clay bricks. A. T. GREEN AND L. S. THEOBALD. *Trans. Ceram. Soc.* (Eng.), **24,** 124–58 (1924–25).—Samples of fire bricks were withdrawn from 4 kilns at various stages during the firing and data concerning them detd. The true sp. gr. data indicate chiefly the change in the kaolinite mol. progressing from about 450° to 570°, the polymerization of the alumina mol. about 950° and some considerations respecting the vitrification range. The range of max. porosity and the other facts concerning the vitrification range are shown by the true and apparent porosity detns. The "loss on ignition" data give an indication of the commencement of the dehydration of the kaolinite and allow a time-factor during which water-vapor is being evolved from the clay subs., to be obtained. The detns. of vol. contraction substantiate the conclusions appertaining to the vitrification range, based on sp. gr. and porosity data. Visual observation of the specimens gives valuable information concerning the elimination of carbonaceous matter the appearance of "iron" specks and blotches, the color changes taking place during firing and the vitrification of the products. H. F. S.

Some fallacies to be avoided in the standardization of any method of testing the load-bearing capacities of refractories at high temperatures, and a suggested method for standardization. A. J. DALE. *Trans. Ceram. Soc.* (Eng.), **24** [2, 3], 216–27(1924–25).—It is suggested in this paper that methods which involve rapid application of load are unsuitable as standardized methods of testing the load-bearing capacities of refrac. mats. at high temps.; methods which require the penetration of loaded rods into the mat. are also of questionable value. Any method of testing the load-bearing capacity of fire brick mat. at high temp. is to be avoided, from the standardization viewpoint, if it involves merely one detn. of the amt. of subsidence at a fixed temp. and under a fixed load. The results from such a test will not necessarily place the mats. in order of merit from the practical load-bearing point of view. Any high temp. load-test on fire clay products which involves merely the recording of the temp. (or cone) at which collapse takes place, under a fixed load, and constant rate of rise of temp., may also yield anomalous results. H. F. S.

Dolomite as refractory material. ANON. *S. African Jour. Sci., Eng. and Mining Jour.-Press,* **120** [5], 177(1925).—Dead burned dolomite mixed with some impurity is the best refrac. mat. available to the steel industry. Results obtained by the U. S. Bureau of Mines, Ohio State University, show that with 90% dolomite and 10% flux the best results are obtained. This compn. is found naturally in the dolomites of the Transvaal. Dolomites in this region cover an area of approx. 8500 sq. mil. These dolomites vary in compn. from 74% to 94% lime and magnesia. A dolomite contg. 10% fluxes consisting of silica, iron oxide, alumina and manganese is now used in the Transvaal iron and steel fur. For open hearth fur. the dolomite without calcination is crushed to a coarse powder and spread over the bed of the heated fur. in a bath of molten iron.

For hearths in the elec. fur. the dolomite is dead burned, ground to 4-mesh and mixed with melted tar. Dolomite in this district also has possibilities for the manuf. of paper pulp. See *Ceram. Abs.*, **8** [8], 221(1925). H. G. F.

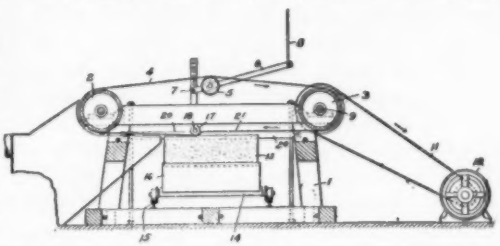
Magnesite mining at Red Mountain, California. GEORGE J. YOUNG. *Eng. and Mining Jour.-Press*, **120** [57], 178–80(1925).—Serpentine is the prevailing rock from which magnesite is derived by alteration, in this region. Drifts are extended into the veins or lenses along fracture zones at 3 or 4 levels. The magnesite is picked by hand, approx. 50% of the broken mat. being rejected. A bucket tram deposits the sorted magnesite at the calcining plant. Shaft and rotary calciners are used. The lump magnesite is subjected to a slow heat in the shaft of the upright fur. and to a high heat in the firing zone, the calcined mat. is removed at regular intervals. Two grades of calcined product are shipped, No. 1 white and No. 2 slightly colored. The magnesite is of high quality and suitable for plastic purposes. H. G. F.

Qualities of firebrick from a metallurgical standpoint. W. GRUM-GRJIMALLO. *Feuerfest*, **1** [1, 2, 3], 19(1925); *Blast Fur. and Steel Plant*, **13** [9] (1925). Abstracted in *Ceram. Abs.*, **4** [10], 278(1925). H. G. F.

PATENTS

Composite refractory body. JOHN WESLEY MARDEN and HENRY KNEELAND RICHARDSON. U. S. 1,554,225, Sept. 22, 1925. As an article of manuf. a composite body comprising a ceramic refrac. mat. to at least part of the surface of which a substantial layer of practically pure thorium oxide is affixed. The method of producing a composite refrac. body which comprises preparing a slip of finely divided thorium oxide, a salt adapted to function similarly to a colloid, a medium adapted to precipitate any colloid and to produce a suitable consistency for casting, subsequently applying the thus formed slip to ceramic mat. and drying.

Apparatus for dressing clay blocks. LEE SHOWERS. U. S. 1,554,925, Sept. 22, 1925. App. for dressing clay blocks comprising an abrading belt, a pulley for driving the belt, means for supporting a block with the surface to be dressed in opposition to the abrading surface of the belt, and a presser member of circular cross-section having a diameter less than one-half that of said pulley mounted for rotation back of the belt and extending transversely thereof in opposition to the block, the block and presser member being mounted for relative movement so as to permit the portion of the belt opposite the presser member to contact with the block during such relative movement.



Refractory material. G. S. FULCHER. Can. 248,315, Mar. 31, 1925. A cryst. refractory contains SiO_2, Al_2O_3, zirconia and alk. silicate. (*C. A.*)

Terra Cotta

A dollar for every terra cotta crack. ANON. *Brick and Clay Rec.*, **66** [10], 746 (1925).—A description of the many unusual features at the Advance Terra Cotta Co. plant at Chicago Heights, Ill. F. G. J.

White Wares

Can you use these ideas? ANON. *Brick and Clay Rec.*, **67** [4], 261(1925).—Many new production features described in the new sanitary pottery plant of Thomas Maddock's Sons Co., at Trenton, N. J. F. G. J.

Latest German insulator designs. ANON. *Ceram. Ind.*, **4** [6], 460(1925). (Translated from *Keram. Rund.*)—This article tells what the Germans are doing in the high tension field. F. G. J.

Seven thousand sanitary ware pieces per week. ANON. *Ceram. Ind.*, **5** [2], 137(1925).—An illustrated description of the new Maddox Sanitary Ware Pottery at Hutchinson Mills, N. J. F. G. J.

Late German electric porcelain development. L. F. THIESS. *Ceram. Ind.*, **5** [3], 219(1925).—Dimensions and prices are standardized but methods of make-up vary. F. G. J.

Templates standardize porcelain output. ANON. *Ceram. Ind.*, **5** [3], 241 (1925).—An illustrated account of the Illinois Porcelain Co., at Macomb, Ill. F. G. J.

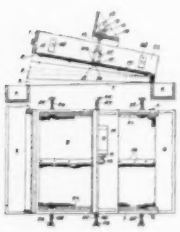
Zircon as a constituent of ceramic bodies. WALTER L. SHEARER. *The Ceramist*, **5** [6], 316–28(1925).—S. discusses the possibilities of using zircon in the making of pottery bodies resistant to sudden temperature changes. S. gives a short history of zircon, a summary of its present sources and its more important characteristics. While zircon has a large coeff. of thermal expansion it is probably free from sudden large changes of vol. such as occur with quartz. More data on the coeff. of thermal expansion of zircon should be obtained. Previous work on bodies containing zircon indicate that they have interesting possibilities. Formulas of bodies that have shown noteworthy resist. to thermal shock when fired to cone 12 are given. Their phys. properties are given. In testing a fired body, the tranverse strength of a 4″ x 1″ x 1″ test bar, which had been heated rapidly to 950°C and quenched rapidly in a current of air from an electric fan, was taken as a measure of its power of resisting thermal shock. Experiments showed that zircon would make a desirable substitute for rather expensive calcined alumina in some bodies. Zircon imparts a high mechanical strength to a body. Formulas for high fire porcelains and porcelains for ball mill linings are given. S. advises compounding by vol. rather than weight due to the high sp. gr. of zircon. Zircon bodies can be successfully cast if the slip is properly prepared. Formulas for slips that cast well contg. 90% and 70% zircon are given. A. E. R. W.

Importance of control of body mixture as a preventive of crazing. J. M. KREGER. *The Ceramist*, **6** [4], 561–4(1925).—K. describes a series of practical tests which throw some light on crazing in glazed porous bodies such as solid porcelain and terra cotta. K. concludes that under the conditions that their particular body is used, a softer and less dense body, as shown by the absorption test, is the more satisfactory. A. E. R. W.

United States Government master specifications for vitrified chinaware. Federal Specifications Board. Specification, No. 243. *The Ceramist*, **5** [6], 334–49(1925).—Specifications of chinaware and diagrams of impact testing app. A. E. R. W.

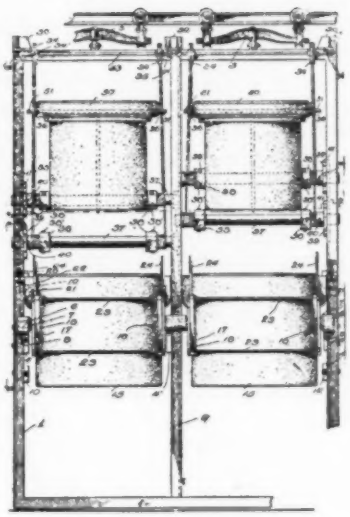
High-voltage (porcelain) insulator development. K. A. HAWLEY. *Elec. World*, **86**, 360–3(1925). (*C. A.*)

PATENTS

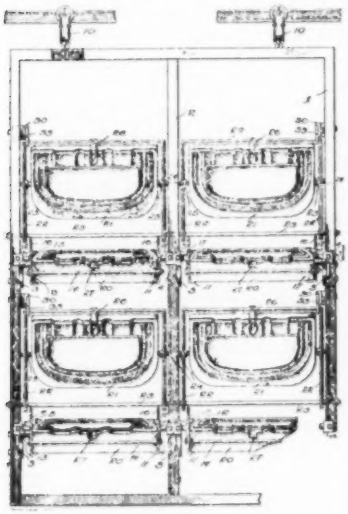


Machine for sifting potters' slip and other granular or pulverulent materials. SYDNEY THOMAS HARRISON AND ARTHUR CECIL HARRISON. U. S. 1,554,821, Sept. 22, 1925. A sifting mach. of the class described, comprising a mesh, an element mounted independently of the mesh for rotation and including an eccentric, a closed casing enclosing the eccentric, ball bearings interposed between the eccentric and the casing and a rod carried by the casing and actuated by the eccentric, said rod being connected directly to the mesh to vibrate the same.

Apparatus for casting pottery ware. EDWARD S. LEA. U. S. 1,557,371, Oct. 13, 1925. App. for casting pottery ware from slip comprising a portable support, a mold pivoted thereon for rotary movement from charging to dumping position and a core suspended on said support above the mold and adapted to be moved into and out of coöperative engagement with the latter.



Apparatus for casting pottery ware. EDWARD S. LEA. U. S. 1,557,372, Oct. 13, 1925. App. for casting pottery ware from slip comprising a portable support, a mold section pivoted thereon for rotary movement from charging to dumping position, a frame pivoted to said support above the mold section and a second mold section pivoted in said frame and adapted to be swung into and out of engagement with the first mold section by the movement of said frame.



Equipment and Apparatus

Are pyrometers saving money for you? They will if used and not abused. ANON. *Ceram. Ind.*, **4** [6], 444(1925).—The first of a series showing how to use the pyrometer as a cost cutting agent. F. G. J.

Pyrometers—cost cutting agents. ANON. *Ceram. Ind.*, **5** [1], 30(1925).—A detailed description in simple terms of the mechanism of pyrometry. F. G. J.

Optical and radiation pyrometers in ceramic plants. ANON. *Ceram. Ind.*, **5** [2], 123(1925).—Advantages and disadvantages of this type of instrument. F. G. J.

Handling raw material. ANON. *Brick and Clay Rec.*, **67** [3], 185(1925).—A few pointers on different types of equipment and hints on the proper installation of belt conveyors and bucket elevators. F. G. J.

Fire clay ware in electric tunnel kiln. ARTURO PAOLONI. *Brick and Clay Rec.*, **67** [3], 196(1925). (Translated from *Keram. Rund.*, 2(1925).)—An account of a tunnel kiln going to 1400–1500°C with radiating rheostats of granulated artificial graphite supported by walls of silicon carbide. F. G. J.

Would electric trucks help you? H. J. PAYNE. *Brick and Clay Rec.*, **67** [4], 256(1925).—Describes the use of elec. industrial trucks on clay plants. F. G. J.

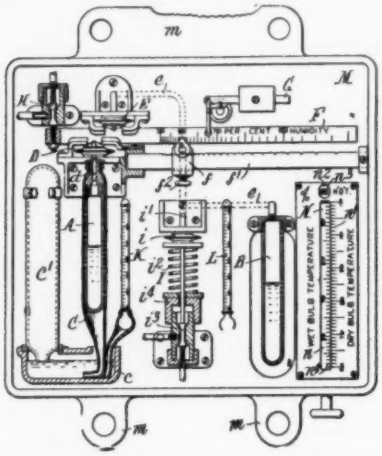
Saves labor of ten miners. ANON. *Brick and Clay Rec.*, **67** [5], 330(1925).—The Globe Brick Co., Kenilworth, W. Va., uses an elec. loader and 3 elec. locomotives in their clay mine. F. G. J.

Further experience with the Dorr mill. A. S. W. ODELBERG. *Trans. Ceram. Soc.* (Eng.), **24** [2, 3], 268–72(1924–25).—In a previous paper (*Trans.*, **22**, 2(1923))

the Dorr Mill Plant as arranged at Gustavsberg was described. Since that time, the grinding has been made perfectly automatic; by opening the tap under the thickener, the finished mat. is allowed to run constantly to the flint arks. The work of the man supervising the grinding is reduced to that of an onlooker. A great advantage of this automatic regulation is that the circulation of the mat. takes place without shock or disturbance at any point or time. This is clearly shown in the thickener, where periodical cloudiness is no longer observed at the overflow. It has been proven that the Dorr mill product is of more uniform grading while that of the batch grinding gives a wider range of particles. According to experience, the Dorr product is more suitable for making good earthenware, as it is absolutely similar to the flint produced by the old pans in conjunction with "washing up." Apart from the possibilities of perfecting the process, the writer is convinced that no more scientific and easily regulated method of wet grinding minerals has yet been found, but this grinding plant is used only where a large output is required, 50 tons per week, as the work ought never to be intermittent. H. F. S.

Dielectric loss measurements on commercial insulating materials. C. DANNATT. *World Power*, **4**, 141–4(1925).—D. describes a complete testing equipment designed for lab. tests. The design, calibration and performance of an oil-immersed electrostatic wattmeter are described. (*C. A.*)

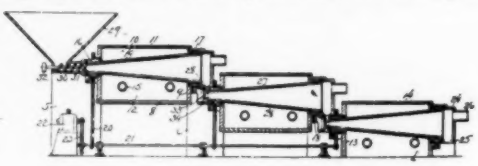
PATENTS



Humidity and temperature regulator. WILLIS H. CARRIER. U. S. 1,554,784, Sept. 22, 1925. In a humidity regulator, the combination with a humidity supply system and a valve operable to control the action of said system; of a rocking lever for effecting the operation of the valve, and thermoresponsive elements independently influenced by different temps., and connected to the lever at points unequally separated lengthwise of the lever from the pivotal axis of said lever, the movement of the lever being dependent upon the relation existing between said different temps., substantially as set forth.

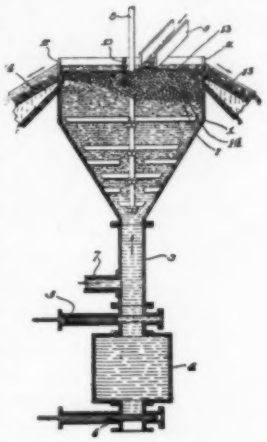
Humidity regulator. WILLIS H. CARRIER. U. S. 1,554,785, Sept. 22, 1925. In a humidity regulator, the combination with a valve operable to control humidity; of thermoresponsive elements independently influenced by different temps., said elements being arranged and operating differentially due to changes in temp. affecting them to produce pressures acting in opposition to each other upon said valve and a motor acting on said valve supplementarily with one of said thermoresponsive elements and in opposition to the other thermoresponsive element, whereby the operation of said valve is dependent upon the relation existing between said different temps.

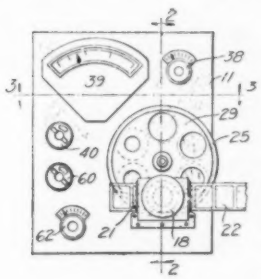
Rotating retort. FREDERIC S. BACON. U. S. 1,556,194, Oct. 6, 1925. A retort comprising a series of end communicating tapered tubes rotatably mounted and arranged in stepped down formation, the smaller ends of the tubes communicating with the larger ends of the tubes, the smaller ends of the tubes forming the inlet, vapor and gas conducting means for the larger end



of each tube, the smaller receiving end disposed below the lower side of the larger end of the adjacent tube, there being a material collecting chamber between each tube and independently controlled heating means associated with each tube whereby gases possessing different chemical properties may be sequestered from each tube.

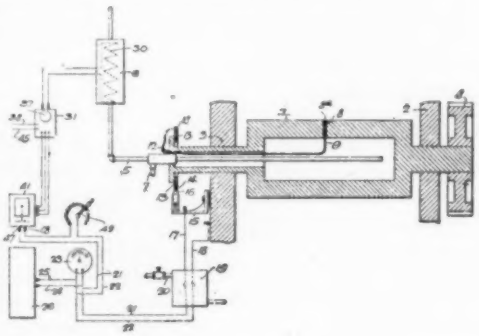
Method for separating materials. THOMAS M. CHANCE. U. S. 1,556,676, Oct. 13, 1925. A method for separating mats. of different specific gravities which consists in immersing said mats. in a maintained suspension in liquid of comminuted solid matter of greater specific gravity than said liquid and substantially insoluble therein and constituting a fluid mass having a specific gravity materially greater than that of the lightest of said materials, the quantity of said materials so immersed being sufficient to form a zone of floating materials of such thickness as to permit said floating materials to stratify in the order of their relative specific gravities; in maintaining the lower portion of said zone of floating materials as a baffle to prevent the heavier falling materials from carrying down the lightest of said materials floating at the top of said fluid mass; in causing materials of greater specific gravity than said fluid mass to sink to the lower part of said fluid mass; in removing the lighter materials floating in the upper portion of said zone of floating materials and in separately removing the materials comprising the lower parts of said zone of floating materials, whereby differential separation of the said floating materials is effected into grades of different specific gravities and in separately removing said heavier materials from the lower part of said fluid mass.



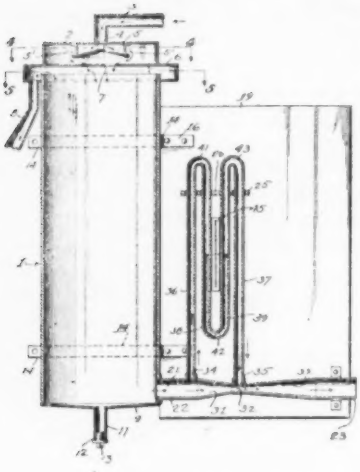


Device for measuring the opacity of translucent materials. VINCENT C. DE YBARRONDO. U. S. 1,556,766, Oct. 13, 1925. In a device for measuring the opacity of translucent substances, the combination of: a cell of changeable resistance under the influence of light rays; a luminous body; means for interposing a body of translucent substance between said cell and said luminous body; a source of electric current in circuit with said cell; an indicating instrument in said circuit; and a variable resistance shunted across said source of electric current to form a branch circuit of variable resistance for controlling the flow of electric current in the circuit of said cell.

Electric temperature control. CHARLES B. THWING. U. S. 1,557,387, Oct. 13, 1925. The combination with a roll of an element mounted adjacent to the working surface thereof and forming with said roll a thermoelectric couple, said element having different thermoelectric properties from the roll.



Viscosimeter. FRANZ P. ZIMMERLI. U. S. 1,557,517, Oct. 13, 1925. In a viscosimeter, the



combination with a container adapted to contain a substance of undetermined viscosity, an inlet pipe in the top thereof, baffle plates against which the incoming liquid is diverted as it enters the container, and an overflow outlet near the top of the container for the discharge of the excess or fluid undergoing test, of an outlet pipe narrowed at the throat extending laterally from the bottom of the container, a U-tube adjacent thereto with a measuring liquid therein, means connecting the U-tube with the outlet tube, whereby a vacuum is produced in one leg of the U-tube and a pressure in the other leg thereof, and a calibrated scale for registering the differences in the levels of the measuring fluid in the respective branches of the U-tube.

Kilns, Furnaces, Fuels and Combustion

Positive heat transfer in tunnel kiln. E. W. EKSTRAND. *Brick and Clay Rec.*, **66** [10], 753(1925).—Advocates flat arch, transverse passages in car decks and other features for uniform heat treatment. Describes kiln at Vitrefrax plant. F. G. J.

An automatic electric heater. ANON. *Fuels and Fur.*, **3** [9], 1043(1925).—An automatic elec. heater for keeping fuel oil warm near burner and at constant temp., thus aiding in atomization. R. M. K.

Well-typed burner for pulverized coal. H. W. BROOKS. *Fuels and Fur.*, **3** [9], 1047-8(1925).—The burner is described as well as a fur. in which it was used. The principle of "turbulent flow" was explained. R. M. K.

A study of kiln losses. G. A. BOLE. *Brick and Clay Rec.*, **67** [4], 264(1925).—An account of the results of the kiln investigation of the U. S. Bur. Mines. F. G. J.

The heat insulation of kilns and other high-temperature installations. A. T. GREEN. *Trans. Ceram. Soc.* (Eng.), **24** [2, 3], 240–61(1924–25).—The selection of insulating mat. for high temp. work cannot be based on insulating efficiency alone. Before selecting such a mat. it is absolutely essential to have a complete knowledge of the circumstances of its future use, particularly regarding the face temp., to which it will be subjected. The following data will then serve well in the selection: The coefficient of thermal condy. at temp. between 300° and 800°C, or the insulating efficiency based on a test simulating indus. conditions; percentage porosity, together with some description of the nature of the pore-spaces; refractoriness, together with the temp. at which the mat. disintegrates or otherwise loses its structure; crushing strength as an indication of the mech. strength. H. F. S.

Selection of fuels and furnaces. W. TRINKS. *Fuels and Fur.*, **3** [9], 937–56, 1019–24(1925).—The subject is discussed under the following outline: 1. Introduction; 2. Sources of heat energy; 3. Utilization of heat; 4. Method of heat transfer; 5. Method of heat application; 6. Selection of fuel or heat energy to suit plant conditions; 7. Selection of type of fur. to suit plant conditions; 8. Method of handling materials. These items are compared in making any selection of fuels and furnaces. In the introduction it is stated that engineering rules and formulas, in the selection of fuels and furnaces, cannot be strictly followed when considering a given process. It

is necessary to take econ. and human factors, as well as technical factors, into account when considering such problems. That fur. and fuel should be selected which, in the heating of the material, will contribute most toward lowering the cost of a perfect finished product. Seventeen items are listed which influence the cost. Two sources of heat energy are mentioned, namely (1) heat energy derived from elec. energy and (2) heat energy derived from the combustion of fuel. Particular conditions should det. which source should be used. Recuperation, regeneration and preheating are discussed and sample calcns. are given to use to det. cost and profit of these heat recovery processes. In discussing the method of heat transfer advantages of direct fired and muffle fired furnaces and salt baths are given. Methods of suspending "stock" are given. Under fired, side fired and side fur. are described and calcns. given. If more than one fuel is available, one should study each of them in the light of plant conditions and costs. In selection of fur. to suit plant conditions, one should take every possible item of costs, layout, etc., into consideration. A questionnaire is given which shows the nature of the data that should be obtained before buying or installing a fur. The main purpose of the author is to point out some of the many variables to be taken into consideration in selecting a fur. and to urge that each case be considered in the light of the variables which have been pointed out. R. M. K.

Automatic temperature control of fuel fired furnaces. HUNTER DICKSON. *Fuels and Fur.*, **3** [9], 1027–30(1925).—Motor operated valves are the most recent development in the automatic control of fuel. Diagrams of an automatic fuel control system together with methods of operation and charts show uniformity of regulation. Under conditions where it is possible to regulate temp. reasonably well by hand, it is possible by the use of well designed equipment to produce constant uniform heat, good furnace conditions and provide max. fuel saving. R. M. K.

Auxiliary equipment for oil burning. KESTER MILLER. *Fuels and Fur.*, **3** [9], 1007–14(1925).—A diagram of a complete oil handling system is shown and the system described. Calculations are given for obtaining the correct pipe sizes. Many suggestions are given regarding size, shape and location of storage tanks. Several types of gages for indicating quantity of oil in storage are described. R. M. K.

Note on powdered coal burning. ANON. *Fuels and Fur.*, **3** [9], 1018(1925).—The fur. is the most important part of any pulverized coal burning equipment. The highest thermal efficiency is effected by using low excess air, but this practice gives high fur. temp. thus causing erosion of the linings and fusion of coal ash. Suggestions are given for remedying these difficulties. R. M. K.

Influence of pulsations on combustion. JULES DESCAMPS. *Fuels and Fur.*, **3** [9], 957–8(1925).—The author develops his discussion on the premise that correct functioning of a fur. depends upon the means employed to insure that the draft is distributed over the largest portion of the fuel surface and in the most uniform manner. In gas producer firing, "flues" or air-ducts are formed in the fuel bed and thus prevent proper surface exposure to air. The effect of these flues is partially counteracted by poking and agitation. It is recommended that combustion be stimulated by producing lateral movements of air in the coal bed thus enabling more fuel surface to be exposed to the air and aiding in counteracting the formation of vertical air-ducts. The author's pulsation method for creating transverse movements is described. R. M. K.

Tunnel kilns for fire brick production. W. POHL. *Feuerfest.*, **1** [9], 87(1925).—An illustrated description of the tunnel kiln built by the "Keram. Ind., Bedarfs A. G.-Dresden." Over 30 now in service. Secondary air for combustion preheated to high temp. and quantity controlled irrespective of stack draft. F. A. W.

Testing the fineness of pulverized coal. ANON. *Mech. Eng.*, **47** [10], 822(1925).—It is pointed out that the method of testing the fineness of pulverized coal by passing it

through standard 100-mesh and 200-mesh screens may be at fault in showing the actual pulverizing work done. This test should be supplemented by a microscopic examn.

C. J. H.

Combustion control by means of triangular diagrams. THÉODORE SUNNEN. *Chaleur et industrie*, **6**, 266–9(1925).—Description and explanation of a graphical method for controlling combustion, more particularly of blast-furnace gases, by means of triangular coördinates (representing CO_2, CO and O_2) having as parameter the ratio of (air actually used): (air theoretically required). When 2 of the quantities have been detd. by analysis, the other 2 can be read directly from the diagram. (*C. A.*)

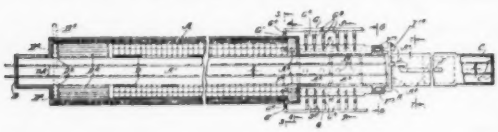
New electric furnaces for the ceramic industries. ARTURO PAOLONI. *Rev. électrochim.*, **18**, 205–15(1924).—P. has designed a furnace having a "mass resistor" of graphite grains the resistance of which can be kept nearly const. by the addn. of more resistor material as it is needed. The heat generated in the "mass resistor" is transmitted to the heating chamber through a partition of crystd. SiC. By cutting channels into these partitions the temp. in the heating chamber reached 1450°. This type of furnace may have a single heating chamber and 2 "mass resistors" or 2 heating chambers and 3 "mass resistors." They have been used successfully, in sizes up to 240 kv. a., in baking ceramic products. In actual practice 40–50 kw.-hrs. were used per kg. of porcelain baked; 2500 kw.-hrs. baked 550–600 refractory bricks at 1300°.

(*C. A.*)

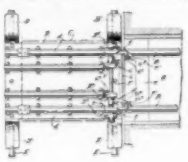
PATENTS

Furnaces for high temps. ANON. Eng. Pat. 234,877, *Colliery Guar.*, **130**, 580 (1925). Two water drums connected to the steam drum by water tubes. The whole forms the shell for the actual combustion chamber; the spaces between the water-tubes are filled up by shaped brick made of refractory materials. The tubes can be subjected to the heat produced within the combustion chamber. The projections of brickwork, which protrude into the chamber, serve as heat retaining or absorbing members. By this means there is produced a channel-shaped chamber, in which the actual combustion of the injected fuel is effected. If the mixt. of fuel and air is injected from one side and ignited by means of a flame, the brick absorb a part of the heat, and a further part is transferred to the water in the boiler through the water-tubes. If, for instance, a temp. of 1700° to 1800° were produced in a combustion chamber made solely of brick, a temp. of about 1400° would result in the combustion chamber by the absorption of the radiant heat. This temp. may be raised or lowered by corresponding construction or suitable dimensions of the ht.-retaining or ht.-conducting surface. The shaped brick are not fitted in the bottom of the combustion chamber between the water pipes, as in the side walls, but in the reverse position, so that the bottom of the combustion chamber presents a substantially flat surface. O. P. R. O.

Salt glazing and kiln for same. CONRAD DRESSLER. U. S. 1,556,208, Oct. 6, 1925. The method of glazing ceramic ware which consists in moving the ware through an elongated kiln chamber, cooling an exit end portion of the kiln chamber and heating other portions thereof as required to glaze fire and then cool the ware in its passage through the chamber,



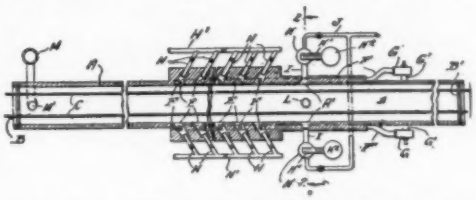
maintaining a reducing atmosphere containing a vaporized glazing agent in a high temp. glazing zone portion of the chamber.



Tunnel-kiln-car construction. PAUL A. MEEHAN. U. S. 1,556,294, Oct. 6, 1925. A transfer car provided with a track over which a car can be moved onto and off the transfer car and

formed in sections, one of which comprises a frame hinge connected the transfer car and track rail parts detachably connected to said frame.

Construction and operation of tunnel kilns. ROBERT W. STEERE. U. S. 1,556,260, Oct. 6, 1925. The method of firing and surface finishing ceramic ware which consists in passing the ware through an elongated kiln chamber of a continuous tunnel kiln heated to first raise the ware to a maximum temp. and then to cool the ware as the latter is moved through the kiln chamber from one end to the other, and injecting a finely divided solid material into a high temp. portion of the kiln chamber to thereby produce surface markings on the ware and restricting the dispersion longitudinally of the kiln out of said high temp. kiln portion of said solid material and the gases formed therefrom.



Geology

The Swedish feldspar industry. A. S. W. ODELBERG. *Trans. Ceram. Soc.* (Eng), **24** [2, 3], 275–7(1924–25).—The feldspar industry is fairly widely scattered over the country, but the largest outcrops are to be found in the Baltic Archipelago in the neighborhood of Stockholm. The feldspar produced in Sweden is chiefly orthoclase. In a few of the mines albite (soda feldspar) is also found but in minor quantities. The average production per annum during the last 15 yrs. has amounted to 9500 tons. The greatest annual production shows 14,400 T. of which 8000 T. are first quality feldspar. H. F. S.

The mining and preparation of feldspar and flint. W. M. MYERS. *The Ceramist*, **6** [2], 438–51(1925).—A report on the occurrence and methods of mining and prepn. of feldspar and flint. A. E. R. W.

The natural history of the pegmatites. FRANK L. HESS. *Eng. and Mining J. Press*, **120** [8], 289–98(1925).—The presence of huge crystals and great masses of single minerals in pegmatites gives rise to the question as to their mode of origin and call for explanations of various phenomena. Numerous individual cases of crystals and mineral masses are discussed. The facts can best be explained by a study of the "long continued flow of soln.," theory. This allows for the possibility of the resolution either wholly or in part of previously solidified minerals, and their redeposition in other parts of a vein or dike. Numerous references are cited. H. G. F.

Nickel ores. W. G. RUMBOLD. Imp. Inst. Res. Bur., *Monograph*(1923).—Nickel ores: their occurrence, character and uses; sources of supply; world map of nickel deposits and bibliography of lit. of nickel are discussed. Reference is made to the use of nickel oxide in the ceram. indus. O. P. R. O.

Tungsten ores. RASTALL AND WILCOCKSON. Imp. Inst. Res. Bur., *Monograph* (1920).—Tungsten ores: their occurrence, character and uses; sources of supply and bibliography are included in this monograph. Reference is made to the use of tungsten trioxide for imparting color to glass and porcelain. O. P. R. O.

China clay. ANON. Imp. Inst. Res. Bur., *Bull.* **22,** 208(1924).—Mineral resources of Bulgaria. China-clay is found and worked at three places in northern Bulgaria. O. P. R. O.

Bauxite—Greece. ANON. Imp. Inst. Res. Bur., *Bull.* **22,** 82(1924).—M. Georgalas, Dir. Geol. Bur. of Greece, describes (in *L'Echo des Mines et de la Métallurgie*, March, p. 138 (1924)) a recent discovery of bauxite on the shores of the Bay of Aspra-Spitia, in the Gulf of Corinth. Two samples contd. 54.35 and 57.52% of alumina,

respectively, while in both cases the percentage of silica was low and the titanium dioxide was practically absent. Bauxite has been found in 5 different points over a fairly large area. O. P. R. O.

Bauxite—India. C. S. Fox. Geol. Surv. of India, *Mem.* **49,** 1(1923).—A comprehensive acct. of the bauxite and aluminous laterite occurrences of India. Beds of rich bauxite ore have been found in several different localities. O. P. R. O.

Fire clay. Anon. Min. and Geol. Inst. of India, *Trans.*, **20,** 181(1925).—The fire clay resources of India are believed to be practically inexhaustible. Lithomarge, kaolin, fullers' earth and bauxite are also found in India. O. P. R. O.

Tin ores. G. M. Davies. Imp. Inst. Res. Bur., *Monograph*(1919).—Tin ores: their occurrence, character and uses; sources of supply and bibliography. In the ceram. industries stannic oxide is extensively used to form an opaque white in enamels, glazes and glassware. A blood-red glaze is produced by compds. of tin and chromium, while purple of Cassius is a compd. of tin and gold. Stannic sulphide is employed as a gilding mat. under the name of mosaic gold. Various pink, lilac, blue and green pigments contain tin, but they are of comparatively little importance. A mixt. of tin and lead oxides forms putty powder used in polishing glass, stone and metal. Under the name of tin ash it is used also in the pottery industry. O. P. R. O.

Non-metallic minerals. Anon. Imp. Min. Res. Bur., *Monograph*(1925).—Aluminium (including bauxite and cryolite), barium minerals, bismuth, borates, cadmium, china clay, chrome ore and chromium, cobalt, feldspar, fluorspar, fullers' earth, magnesite. Statistics for 1920–1922. O. P. R. O.

Chromium ore. W. G. Rumbold. Imp. Inst. Res. Bur., *Monograph*(1921).—Chromium ore: its occurrences, character and uses; sources of supply of ore; world map of chromite deposits and bibliography of lit. are dealt with in this monograph. Especial mention is made of the importance of chromite as a basic refrac.; and further that chromic acid, chrome yellow and chrome green are chiefly used as pigments in decorative painting and also in the ceram. indus. They form the color base of many beautiful pigments and glazes. O. P. R. O.

Physical chemistry of igneous rock formation. J. S. Flett. Discussion held by the Faraday Soc., Geol. Soc. and Mineral. Soc., October, 1924, 414–7.—A general review of the work in this field is given with special mention of the researches in the Geophysical Lab. at Washington. (*C. A.*)

The kaolin deposit of Bettole at the foot of Monte Fenera, Val Sesia. Allessandro Roccati. *Rass. min. met. chim.*, **62,** 53–6(1925).—Besides the kaolin used in large quantities for refractories, another type is present which in its cryst. form resembles soapstone. It has a waxy luster and an unctuous feeling, a hardness of 2.5, d. 2.2–2.6, n 1.53–1.54 and m. p. 1750–1790°, and varies in color from green to milky white to reddish, though it approaches transparency in very thin scales. It is composed of alternate layers of amorphous and cryst. kaolin, the latter being active with polarized light. Analysis shows the kaolin, including the milky white variety, to have the compn. $H_4Al_2Si_4O_9$. At 250° for several hrs. it loses 1.40–1.70% H_2O, the remainder being liberated only at a high temp. The natural kaolin is probably an intimate mixt. of true kaolin and halloysite, the latter accounting for the amorphous component and for the loss of H_2O at a low temp. (*C. A.*)

Chemistry and Physics

The heat-insulating efficiencies of some diatomaceous earth products and slag wool. A. T. Green and H. Edwards. *Trans. Ceram. Soc.* (Eng.), **24**[2, 3], 228–39(1924–25).—There is a definite porosity (apparent sp. gr., consistency or packing density) for mats. of the same constitution, which gives a max. insulating efficiency. Pure diatomaceous

earth packed so as to possess an apparent sp. gr. of 0.34 has a greater insulating effect than the same mat. loosely packed (apparent sp. gr. 0.08), and the same mat. in slab form possessing an apparent sp. gr. of 0.46. The greatest insulating efficiency of slag wool is obtained with a packing of 10 lb. per cubic ft. (apparent sp. gr. 0.16) in low temp. practice. H. F. S.

Refractory nature of common oxides. J. BRONN. *Feuerfest.*, **1** [7], 67(1925).—Curves are given plotting the m. p. of the following binary compds. variedly proportioned. Lime-alumina, lime-magnesia, magnesia-alumina, lime-iron oxide, kaolin-magnesite, kaolin-chrome. F. A. W.

The screening problem. ANON. *Brick and Clay Rec.*, **67** [5], 338(1925).—Discussions by 4 well-known clay products manufacturers. The vibrating screen is gradually replacing the stationary type. F. G. J.

Application of glass, enamels and glazes. I. ED. ZSCHIMMER. *Ceram. Ind.*, **4** [6], 448(1925).—How each science can learn something from the other. *Ibid.*, **II.** ED. ZSCHIMMER. *Ceram. Ind.*, **5** [1], 34(1925).—A plea that mixes be expressed on the basis of percentage compn. in all 3 industries. How you can choose a chem. formula for a glass, glaze or enamel. *Ibid.*, **III.** ED. ZSCHIMMER. *Ceram. Ind.*, **5** [2], 128(1925).—Raw mats. may be classified as (1) constant, (2) variable. For Pt. IV. See *These Abs.*, p. 333. F. G. J.

Rare minerals of ceramics and their uses. II. A. F. GREAVES-WALKER. *Ceram. Ind.*, **5** [1], 28(1925).—This article treats of diatomaceous earth (kieselguhr) and zirconium. *Ibid.*, **III.** A. F. GREAVES-WALKER. *Ceram. Ind.*, **5** [2], 126(1925).—This article treats of mica and pyrophyllite. F. G. J.

The relation of kaolinite to high temperatures. V. ISKYUL. *Pottery Gaz. and Glass Trade Rev.*, **50** [579], 1409(1925).—Report of a paper read at the Russian All Unions Congress of the glass and ceram. indus. He attacked with 10% caustic soda samples of kaolin fired to various temps. and generalizes on the results. F. G. J.

Synthetic aluminum silicate. W. EITEL. *Glastechnische Ber.*, **3** [4], 122(1925).—A review of the story of mullite. F. G. J.

Origin of clay. R. SCHWARZ AND R. WALCKER. *Z. anorg. Chem.*, **145,** 304–10 (1925); *Jour. Soc. Chem. Ind.*, **44B,** 711(1925).—A new theory for the mat. formation of kaolin is based on the fact that when sols. of aluminum hydroxide and silicic acid are mixed in water in the propn. Al_2O_3:$6SiO_2$, there is pptd. a subs. Al_2O_3, $2SiO_2$, $2H_2O$ which on keeping becomes similar to kaolin. It is considered that feldspar first decomposes into KOH, $Al(OH)_3$ and SiO_2 aq., and that these products reunite to form kaolin. H. H. S.

Lower oxides of high melting point. E. FRIEDERICH AND L. SITTIG. *Z. anorg. Chem.*, **145,** 127–40(1925); *Jour. Soc. Chem. Ind.*, **44B,** 712(1925).—The following oxides were obtained by the reduction of higher oxides either by H or C: V_2O_3 m. p. 1970°; V_2O_4 m. p. 1640°, Nb_2O_3 m. p. 1780°, Ce_2O_3 m. p. 1690°, WO_2 1230–1330°; W_2O_5, MoO_2, Mo_2O_5, WO_2 (blue and brown, both m. p. 2230–2330°). From TiO_2 and Ta_2O_5 no lower oxides could be obtd., and the authors doubt whether Ta_2O_4 and Ta_2O_3 exist. H. H. S.

The chemistry of solids. C. H. DESCH. *J. Soc. Chem. Ind.*, **44,** 907–13(1925).—The Presidential address to Section B (Chemistry) of the Brit. Assoc. Adv. Sci. H. H. S.

Potassium from mineral silicates. J. M. DOBRESCU-CLUY. *Chem. Erde,* **2,** 83–102(1925); *Jour. Soc. Chem. Ind.*, **44B,** 643–4(1925).—The soly. in dilute HCl of the 4 minerals, biotite, phonolith, muscovite and orthoclase, is in the order named, and pot expts. on assimilation of potash by plants are in concordance with this order, the difference between biotite and orthoclase being very marked. On the other hand,

the soly. in water satd. with CO_2 did not agree with the pot expts. with regard to potash, though it did with regard to phosphoric acid. The more weathered the mineral, the more easily is the potash assimilated. H. H. S.

Stability relations of the polymorphous system Al_2SiO_5. F. NEUMANN. *Z. anorg. Chem.*, **145,** 193–238(1925); *Jour. Soc. Chem. Ind.*, **44B,** 711(1925).—Andalusite, disthene, sillimanite and mullite (62.89% Al_2O_3, 37.11% SiO_2) were investigated by spec. ht. detns. and the application of Nernst's heat theorem. From abs. zero to 1487° sillimanite is the stable modification, while at higher temps. andalusite is stable. Disthene is totally unstable up to 1300° in the disthene–sillimanite system. Andalusite at 1200° is converted into mullite and amorphous silica. Disthene is similarly changed to 1400° but sillimanite appears to undergo no change on heating. H. H. S.

Inexpensive method for determining lead. W. W. SCOTT. *Ind. Eng. Chem.*, **17,** 678(1925).—Dissolve the $PbCrO_4$ ppt., produced in the usual way, in HCl and NaCl mixt. and titrate the chromic acid with $FeSO_4$, using diphenylamine as indicator. Not more than 10 cc. of 12 *N* HCl should be present in 150 cc. of soln. or the addn. of acetate is necessary to reduce the acidity. (*C. A.*)

Electrical conductivity and coagulating power of acids and of bases. G. ROSSI AND M. ANDREANELLI. *Gazz. chim. ital.*, **55,** 99–103(1925).—Experience has shown that solns. of acids and bases having the same elec. condy. do not have the same coagulating power toward negative and positive colloids, resp. This property depends on many factors and cannot be expressed by so simple a law as that of Hardy. Perrin (*J. chim. phys.* **3,** 50(1905)) modified this law thus: The coagulation of a negative hydrosol by means of various acids is brought about by means of solns. contg. the same no. of H ions and also, basic solns. that have the same coagulating power for a positive hydrosol contain the same no. of OH ions. These statements consider the phenomenon as purely elec. but if the phenomena of positive and negative adsorption described by R. that lead to neutralization of the particle and to coagulation (*C. A.*, **18,** 3510) are taken into account, P.'s statements are not adequate. Moreover the coagulating power of the same solns. of acids may become inverted in 2 different negative colloids. In fact a given soln. of HCl coagulates a soln. of As_2S_3 more effectively than a soln. of H_2SO_4 having the same sp. elec. condy. as that of the HCl, but the same H_2SO_4 soln. has a greater coagulating power than the HCl soln. toward a colloidal soln. of Congo red. The latter observations are just the reverse of what is to be expected in terms of P.'s generalizations. (*C. A.*)

Properties and origin of zeolites. O. WEIGEL. *Sitzungsber. Ges. Beförder. Naturwiss. Marburg,* **1924,** 73–101; *Chem. Zentr.*, **1924,** II, 2239.—In the formation of zeolites, where the silicate atoms have assumed a comparatively rigid lattice orientation, the solvent in which the crystals form remains within the lattice meshes, without however, contributing to the lattice structure. Energy is lost through overcoming the internal pressure of the solvent and this energy aids in the erection of the lattice. The latter retains its rigidity under various conditions and the energy of the internal pressure is free and serves to bind foreign substances. The ready exchange of bases is explained by weakened bonds in the silicate lattice. The relation between temp., the vapor pressure of the surroundings and the amt. of adsorbed foreign mols. can be expressed by a modified van der Waals' equation: $n = n/b - [R(T-T_s)v^2]/[(v-nb)(\sqrt{-aa'})]$, the derivation of which is given in the original, n being the no. of adsorbed mols. on a silicate mol., R the gas const., T the abs. temp., T_s the temp. of the satn. pressure of the liquid phase of the foreign substance which itself is a temp. T in the medium surrounding the crystal, a the van der Waals' const. of the medium in which the zeolite forms at the temp. and pressure involved and b a const. The equation has within certain limits given results conforming well to the exptl. material available. (*C. A.*)

The direct determination of tervalent iron in acid-insoluble silicates. The accuracy of the method for determining the valency of iron by attacking the silicate with hydrofluoric and sulphuric acids. O. HACKL. *Z. anal. Chem.*, **66**, 401–30(1925).—The common practice in the analysis of silicates is to det. the total Fe in one sample and in another sample the ferrous Fe after attack by HF and H_2SO_4. In many cases, it is better to det. the ferric Fe directly, rather than by difference, making use of the reaction with $TiCl_3$ and thiocyanate as indicator. In this paper the results of an exhaustive study of all the factors influencing the accuracy of such a method are described in detail. In the first expts. a 0.025 *N* $TiCl_3$ soln. was used and was prone to oxidation but with 0.1 *N* $TiCl_3$ in dil. HCl, the soln. was stable without changing its titer in 2 months, under an atm. of CO_2. During the treatment of material with HF and H_2SO_4 under CO_2, there is always danger of oxidizing a little Fe but if care is taken this error should not correspond to more than about 2 mg. Fe_2O_3. Strong diln. should be avoided. The presence of HF interferes but the error is overcome to a large degree by adding a large excess of H_3BO_3. For 1 g. of rock powder, a little water, 7 cc. of HF and 10 cc. of 18 *N* H_2SO_4 are recommended. After heating 7 min. in CO_2 transfer the crucible with cover and all to a mixt. of 100 cc. 4% H_3BO_3 soln., 50 cc. of water and 5 cc. of 3.3% KCNS soln. Titrate with acid $TiCl_3$ and at the end-point make sure that a drop of ferric soln. causes a permanent coloration with KCNS. (*C. A.*)

Manufacture of boric acid in Tuscany. P. G. CONTI. *J. Soc. Chem. Ind.*, **44**, 343–5T(1925).—A description of present methods and of their historical development. (*C. A.*)

Mechanism of the production of Solvay soda. I. CIOCHINĂ. *Bul. soc. chim. România*, **7**, 24–6(1925).—C. considers that the following are the reactions involved: $CO_2 + NH_3 = NH_2COOH$; $NH_2COOH + NaCl = NH_2COONa + HCl$; $NH_2COONa + HCl + H_2O = NaHCO_3 + NH_4Cl$. (*C. A.*)

The determination of the electrical penetrability of glasses and ceramic materials. M. PIRANI AND H. SCHÖNBORN. *Z. tech. Physik*, **6**, 351–4(1925).—A method is described for the detn. of the temp. of elec. penetrability; a linear relationship exists between this temp. and the elec. condy. (*C. A.*)

Methods of investigation of the ceramic value of feldspars and pegmatites. H. KOHL. *Sprechsaal*, **57**, 361–4, 374–5; *Chem. Zentr.*, **1924**, II, 1974.—Ordinary analysis involving decompn. with concd. H_2SO_4 is unsatisfactory. The method of Kallauner-Matejka (no reference) is superior. The sample is ignited at 750° and is then decompd. by dil. HCl. The feldspar content can be detd. only by chem. analysis and free SiO_2 in an approx. way by the cone m. p. method. More accurate results are possible by optical methods. (*C. A.*)

The mineralogical phase rule. N. L. BOWEN. *J. Wash. Acad. Sci.*, **15**, 280–4 (1925).—A discussion of the mineralogical phase rule (cf. Goldschmidt, *C. A.*, **5**, 3750, 3785) led to the summary "that in all attempts to decide, on the basis of the no. of phases, whether equil. has been attained in a metamorphic rock it is essential to bear in mind the fundamental assumptions as to the no. of components." (*C. A.*)

Silicates. W. EITEL. *Z. Elektrochem.*, **30**, 364–70(1924).—A review of the work of other investigators on the systems SiO_2–Al_2O_3, MgO–SiO_2, CaO–SiO_2, CaO–Al_2O_3–SiO_2, diopside–anorthite–albite, anorthite–forsterite–quartz, SiO_2–K_2SiO_3–H_2O, $CaCO_3$–nepheline. A bomb furnace for the examn. of the equil. between carbonates and silicates under pressure is described and illustrated. (*C. A.*)

Electric charge of clay colloids. D. R. HOAGLAND AND W. C. DAYHUFF. *Calif. Sta. Rept.*, **1923**, 171.—A highly colloidal clay taken from the recently dried bed of Lake Rosamund yielded colloid which was charged negatively by an elec. current at all H-ion concns. between p_H 2 and 12. The presence of cations decreased the intensity of

the charge. No evidence of an isoelec. point was obtained. See *Ceram. Abs.*, **8** [7], 204(1925). (*C. A.*)

The sedimentation of clay and other suspensions. R. E. LIESEGANG. *Sprechsaal*, **56**, 513–4(1923); *Chem. Zentr.*, **1924**, II, 597; cf. *C. A.*, **18**, 2256.—A description of certain phenomena connected with the sedimentation of finely divided $BaSO_4$ (blanc fixe). The latter usually settles and leaves a sharp boundary, *i. e.*, does not leave a supernatant turbidity. But if the $BaSO_4$ is formed, not with a slight excess of sulphate, but with an excess of $BaCl_2$ or with the addn. of glycerol or of gelatin, then a turbidity remains for a long time over the ppt. Moreover the height of the line of demarcation of the ppt. is altered by these added substances. (*C. A.*)

An upper limit for the thickness of the adsorption layer on silica. D. C. JONES. *J. Phys. Chem.*, **29**, 369–75(1925).—Although nitrobenzene is strongly adsorbed from kerosene soln. by SiO_2, no change in concn. was observed on adding 4.65 g. of 120-mesh SiO_2 glass to 3.376 g. of 3.45% soln. A Hilger interferometer capable of detecting a change in concn. of 0.00429 g. nitrobenzene in 100 g. soln. was employed. The upper limit for the thickness of the adsorbed layer of nitrobenzene, on the assumption that the d. is the same as that of the pure liquid in bulk and the mols. are cubical, is about 5 mols. (*C. A.*)

Haveg, a construction material for chemical apparatus. J. K. WIRTH. *Chem.-Ztg.*, **49**, 653–4(1925).—Haveg is composed of bakelite and fibrous asbestos very high in SiO_2. Its sp. gr. is 2.0; its resistance to compression is 800 kg. per sq. cm.; its resistance to bending is 440 kg. per sq. cm.; it is highly resistant to sudden shock; round and sq. tanks up to 6 cu. m. capacity, filter-presses, etc., have been constructed, with Fe reinforcing when necessary; it resists sudden heating and cooling up to 130° (a special quality up to 200°); the heat condy. of ordinary Haveg is not high, but a special compn. serves well for evapg. vessels. It is practically unaffected by 25% HCl, hot or cold, and resists the following reagents unusually well: strong and hot solns. of metallic salts, H_2S, bleach solns., Cl-H_2O, S up to 130°, oxalic, lactic and citric acids and HCOOH up to 40% and H_2SO_4 up to 50%, alc., petroleum, CCl_4 and *aniline salts solns.* (but no aniline). It is attacked by concd. HCOOH, HNO_3, CrO_3, HF, the strong inorg. alkalis, pyridine and aniline (not its salts). (*C. A.*)

The importance of colloid chemistry in mineralogy and geology. C. DOELTER. *Kolloid-Z.*, Spec. No., Apr. 1, 1925, 95–103.—A review which includes a discussion of: (1) transformation of colloid ppts. into cryst.; (2) distinction between colloid and cryst. minerals; (3) formation of colloid minerals in nature; (4) occurrence of colloidal minerals in sediments and (5) the color of colloidal minerals. (*C. A.*)

Rate of decomposition of solid substances. I. Rate of dissociation of magnesium carbonates. M. TZENTNERSHVER AND B. BRUŽS. *Z. physik. Chem.*, **115**, 365–76 (1925); cf. *C. A.*, **19**, 2159.—By measuring the CO_2 evolved, T. and B. measure the rate of decompn. of Mg. carbonates: $MgCO_3$ at 395°; $MgO.MgCO_3$ at 452, 460, 462°; $3MgO.MgCO_3$ at 487°. The reaction is always of the first order and the total process can be resolved in a series of consecutive steps. The reaction const. is an exponential function of the temp. (*C. A.*)

General principles of ion effects on colloids. LEONAR MICHAELIS. *2nd Colloid Symposium Monograph* (Northwestern Univ.), **1924**, 15 pp.(publ. 1925).—The addn. of ions to a sol may produce two effects: (**I**) *direct* or *electrostatic*, due to its fixation (which may be adsorption or chem. combination); (**II**) *indirect, hydrophylic* or *lyotropic* effect due to competition between micelles and dissolved ions for water. Under **I** three possibilities may lead to formation of an elec. double layer: (*a*) *appositional adsorption*, the ion most highly adsorbed detg. particle charge; (*b*) dissociation tendency in colloidal particles; (*c*) orientation of polar water mols. at indifferent surfaces. Silicic acid,

nucleic acids, resin acids (*e. g.*, mastic), etc., are *acidoids*. They are insol., but *tend* to go into soln. and in absence of easily adsorbable ions (Ca, Al) form a layer of H ions which, after Gouy, need not be monomolecular, but may have *diffusivity*. M.'s early view that the surface potential in such cases is due to $C_H{}^+$ in the soln. was not experimentally confirmed. "Evidently the potential asymptotically approaches zero with increasing H-ion concn. This fact is strictly contrary to Nernst's logarithmic law in metallic electrodes." The charge of a metallic H electrode results from the balance between 2 tendencies: the H tends to send H ions into the soln., the electrode remaining negatively charged, while H ions from the soln. tend to settle on the metal and charge it positively. "The abs. zero of charge is given approx. in a p_H equal to 4.5, calcg. from the abs. value of the calomel electrode." Colloidal acidoids also tend to emit H ions and become −, but H ions of the soln. do not tend to settle on the solid particle and charge it +. Colloids like gelatin, casein, etc., may be charged + or −, and have isoelec. points at definite characteristic p_H, depending on the balance between the tendencies: $R.NH_2 + H^+ = RNH_3{}^+$, and $R.COOH = R.COO^- + H^+$. They act like amphoteric electrolytes, and may be called *ampholytoids*. A third group of colloids form double layers without active participation of the colloidal phase, *e. g.*, cellulose, paper, collodion, agar, parchment paper, gas bubbles, in aq. and sometimes even in non-aq. solns. Though generally negatively charged in water, Coehn's law does not hold. While Al salts easily give a + charge to glass, kaolin, mastic, etc., they at most reduce the charge of the third group to zero. As J. Loeb showed, it took quadrivalent Th to make collodion positive. A purely formal explanation of the ionic double layer is that indifferent substances adsorb − ions better than + ions; this "does not involve the supposition that the adsorbent actively participates in adsorption; the real cause of this phenomenon is somewhat problematic." As a working hypothesis M. supposes that OH ions have a greater capillary activity than H ions, so that any aq. interface will be charged − against the mass of water, unless the body touched has forces which disturb the distribution spontaneously aimed at. Orientation of H_2O mols. at the interface might account for the charge, Loeb having found a negative potential of about 7 millivolts with indifferent substances like collodion, graphite and Au. *Flocculation* by electrolytes usually involves adsorption, but this is not so for acids. Thus HCl in great diln. coagulates mastic sol by suppressing the tendency of the mastic to emit H ions, thus destroying the double layer, without being adsorbed. In most other cases *exchange adsorption* occurs, the "original ions" being replaced by other, as per the laws of Hardy and of Schultze. The *Donnan equil.* formulas "may be applied for a limited case of dissociation tendency, namely, for colloidal micellae rich in water." *Agar*, which is always electronegative and shows no isoelec. point, swells most in pure water. All electrolytes up to about 0.01–0.1 *N* concn. reduce swelling, only the valence number of the cation being in evidence. The H-ion is exceptional, its effect exceeding that of tervalent ions. In higher concns. the *lyotropic or Hofmeister series* becomes more and more manifest. A colloidal jelly *Konyaku* (obtained from *Amorphophallus Konyaku*) is entirely without elec. charge, except in presence of many OH ions; and though no ions show any electrostatic effect, in higher concns. (about *N*), "the effect of different electrolytes on the swelling is quite enormous, and does not depend on the valence no. or sign of the charge, but follows the Hofmeister series." Li causes enormous shrinking, while Na and K have a very small effect. (*C. A.*)

PATENTS

Manufacturing red lead. HENRY HOCKING. U. S. 1,556,820, Oct. 13, 1925. The process of making red lead which comprises enclosing lead containing mat. in a pressure tight vessel, simultaneously enclosing in the said vessel rolling bodies made of mat. the melting point of which is considerably higher than that of lead, maintaining within the said vessel a raised pressure by means of an oxidizing gas under pressure and

rotating the said vessel while the charge therein is being heated to a temp. above the melting point of lead.

Production of alkali-silicate solution. LAURENCE WILLIAM CODD. U. S. 1,557,491, Oct. 13, 1925. The process of making alkali silicates of high ratio of silica to soda solutions which comprises subjecting an alkali silicate solution to limited electrolysis without substantial separation of silica until a solution is obtained in which the ratio of silica to soda is less than fifteen to one.

Preparation of chemically pure salts of alumina. ANON. Fr. Pat. 574,983, *Oil and Color Trades Jour.*, **68,** 912 (1925). Bauxite, clay, or similar mineral subs. are dissociated with sulphuric acid, then dissolved in water and the soln. satd. with hydrogen chloride. This ppts. aluminium chloride, which is practically free from iron and is afterwards purified. O. P. R. O.

General

Bureau of Standards investigations of pottery, heavy clay products, glass and enamels. ANON. *The Ceramist,* **6** [5], 621–61(1925).—A digest of the work of the B. of S. in the ceram. indus. during the past year. The following investigations are discussed and the information so far obtained from them given in compact form. **I. Pottery and fine ceram.** (1) Study of commercial feldspars of the whiteware indus. (2) The principles of controlling clay suspensions. (3) Increasing the resist. of glaze on semi-vitreous ware to crazing. (4) The correlation of lab. tests of vitreous tableware with life in actual service. **II. Glass and enamels.** (1) A study of the factors affecting the detn. of viscosity of commercial glasses at working temps. (2) The reln. of the compn. of glass and its phys. properties. (3) The reln. of the compn. and method of manuf. of cast iron to its enameling properties. (4) Vitreous enamels for sheet iron and steel. (5) Principles underlying the properties of enamel suspensions. **IV. Refractories.** (1) The properties of commercial refrac. of the plastic clay type. (2) The properties of fire clay when used as a mortar. (3) Factors controlling the life of tank block in service. **V. Heavy clay products.** (1) Sagger clays, their chem. and phys. properties. (2) The strength of hollow bldg. tile and its possibilities in floor and wall construction. (3) Factors controlling the drying of clays. (4) The mechanics involved in the efficiency of extrusion machines. **VI. Laboratory methods and plant machinery.** (1) Glaze compn. and its effect on resistance to cutlery marking. (2) Novel app. for testing transverse strength of clay lab. specimens. (3) An elec. fur. especially adapted to the detn. of softening points. **VII. Specifications.** (1) Master specif. for vitreous chinaware. (2) Proposed master specif. for fire clay. (3) Proposed master specif. for fire clay brick. (4) Proposed master specif. for plastic fire clay refrac. (5) Work of the standards committee of the AMERICAN CERAMIC SOCIETY. **VIII. Fellowships.** Investigations of pyrometric cones. A. E. R. W.

The clay, clay products and kindred mineral industry of New Jersey. M. W. TWICHELL. *The Ceramist,* **6** [3], 505–11(1925).—Excerpts of interest to ceramists from a pamphlet "The Mineral Industry of New Jersey for 1923" issued by the State Dept. of Conservation and Development. A. E. R. W.

The extent of the ceramic industry. CHARLES F. BINNS. *The Ceramist,* **6** [3], 525–34(1925).—A historical discussion of the origin and development of pottery industries. A. E. R. W.

Ohio manufacturers boost ceramic education. ANON. *Ceram. Ind.,* **4** [6], 445 (1925).—An account of addresses delivered at the joint meeting of the Trades, Technique, and Management Forum of the U. S. Potters' Association and the Ohio Ceramic Industries Association, May 22, 1925. F. G. J.

Spend $1725 and save $8000. ANON. *Ceram. Ind.*, **4** [6], 446(1925).—A comparison of costs of tractors against wheelbarrows. F. G. J.

Raw mats.—their properties and uses. A. F. GREAVES-WALKER. *Ceram. Ind.*, **4** [6], 447(1925).—This article treats of bentonite and andalusite. F. G. J.

Ten thousand tons of china clay by osmosis. ANON. *Ceram. Ind.*, **4** [6], 464 (1925).—An account of clay washing plant. No details of the osmosis machines are given. F. G. J.

What kind of clay drill shall I use? ANON. *Brick and Clay Rec.*, **66** [12], 911 (1925).—Describes the important points of the different types of drills. F. G. J.

Study of clay drying. ANON. Bur. Standards, *Tech. News Bull.*, **101,** Sept. (1925).—Tests were made with differential thermocouples at differential dry and plastic depths in dry and plastic cubes of clay while subjecting to drying conditions. The plastic cubes cracked badly. Max. temp. differences 8°C and 2°C in different tests. F. G. J.

The clay industry of California. ROBERT LINTON. *Brick and Clay Rec.*, **67** [3], 193(1925). F. G. J.

The weathering of clays. W. J. REES. *Pottery Gaz. and Glass Trade Rev.*, **50** [579], 1395(1925).—An address at the Clay Convention. Weathering classed as phys., chem. and organic. F. G. J.

Glues and cements for pottery, glass, etc. ANON. *Pottery Gaz. and Glass Trades Rev.*, **50** [579], 1422(1925).—Recipes. F. G. J.

Ceramic school. E. L. CHICANOT. *Indus. Canada*, **26,** 52(1925).—First ceramic school in Empire. The clay resources of Canada justified to Saskatchewan the establishment of a training school for men to develop the clay products industry of the Province. This school, under direction of W. G. Worcester, was established nearly four years ago; broadly it follows the lines of the ceramic courses at the universities of Ohio and Illinois. The school is well equipped; and further, great hopes are entertained from the use of a new design of kiln to utilize the Sask. lignite coals, the only domestic fuel in the province. O. P. R. O.

Rapid production of vitrified clay ware by combined effect of heat and pressure. A. J. DALE. *Jour. Soc. Chem. Ind.*, **44B,** 717(1925).—Abstracted in *Ceram. Abs.*, **4** [11], 308(1925). H. H. S.

A visit to the osmosis plant at Carlsbad. S. R. HIND. *Trans. Ceram. Soc.* (Eng.), **24,** 73–85(1924–25).—Abstracted, *Ceram. Abs.*, **4** [6], 177(1925). H. F. S.

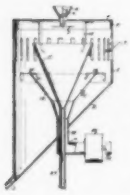
High tribute to Charles Fergus Binns. ANON. *The Clay Worker*, **83** [7], 617 (1925).—At the commencement exercises at Alfred Univ., Professor Binns was invested with the Hood of Honor, made a Doctor of Science, and presented with a Testimonial of Appreciation by the AMERICAN CERAMIC SOCIETY. F. G. J.

Extent of the ceramic field. C. F. BINNS. *The Clay Worker*, **83** [7], 617(1925).—Doctor's oration, covering the history of pottery. F. G. J.

PATENTS

Filtering material and process of preparing the same. DAVID T. DAY. U. S. 1,555,639, Sept. 29, 1925. The process of preparing a filtering compd. from a porous spent shale of a siliceous nature, heating the shale with a strong caustic soda solution whereby the caustic soda enters the pores of the shale and forms sodium silicate with the silica in the pores, adding sulphuric acid to set free silicic acid in the pores, washing the shale with water until free from sodium sulphate, and heating the washed shale to a low red heat until dry.

Process for preparing a filtering material. DAVID T. DAY. U. S. 1,555,640, Sept. 29, 1925. A process for preparing a filtering mat. comprising heating a mixture of shale and alkali and grinding the resulting product.



Process for separating calcined colemanite from clay and other impurities. HENRY D. HELLMERS. U. S. 1,556,110, Oct. 6, 1925. The process for separating calcined colemanite from clay and other impurities which consists in discharging the material to be treated peripherally by centrifugal force in baffling the lighter particles dropping naturally within a limited central area and collecting the particles in a receiving vessel and in drawing certain of the heavier particles dropping outside of the receiving vessel into a second vessel by suction.

Material for resisting oxidation at high temperatures. RUDOLPH F. FLINTERMANN. U. S. 1,556,776, Oct. 13, 1925. An alloy for resisting oxidation at high temperatures containing nickel or cobalt in an amount greater than 20% and less than 60%, silicon in an amount greater than 3% and less than 9% and the balance principally of iron.

AUTHOR INDEX TO ABSTRACTS

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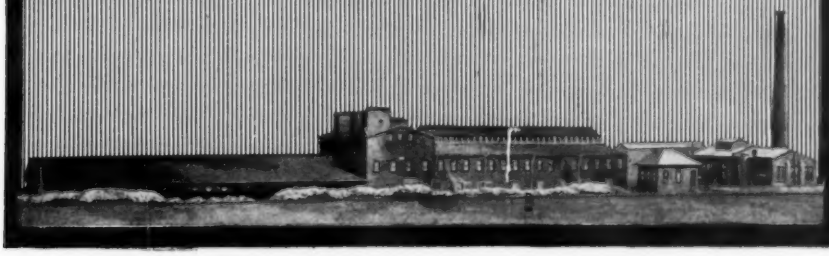

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EDITORIALS

ALLOCATION OF CERAMIC WORK IN FEDERAL BUREAUS

All who have given thought to the many points involved in the general question of allocation of ceramic work between the Bureau of Standards and Bureau of Mines realize that what the bureaus need most is concerted support and coöperation of all the ceramic industries. The allocation details are matters of policy and laboratory direction for which the Department of Commerce is responsible and wholly capable to conduct. Secretary Hoover wants from ceramic manufacturers an organization qualified to advise on character of work to be undertaken and on means of securing the most extensive collaboration of the state and industrial investigation laboratories.

Plant proving of laboratory results has been endorsed because it is practical and conclusive. Results of plant investigations which have been proved should be wholly public property. Special advantages to the plants where the proving is done or to the firms who help finance the work are no more than those involved in "first hand experience." Patent rights on all new disclosures should be assigned to the public, and a minimum of time allowed between the finding of the information and making it known to the public.

The government laboratories should devote most of their resources to fundamental investigations but these investigations should be only such

PROPOSED CERAMIC INSTITUTE RESEARCH ORGANIZATION

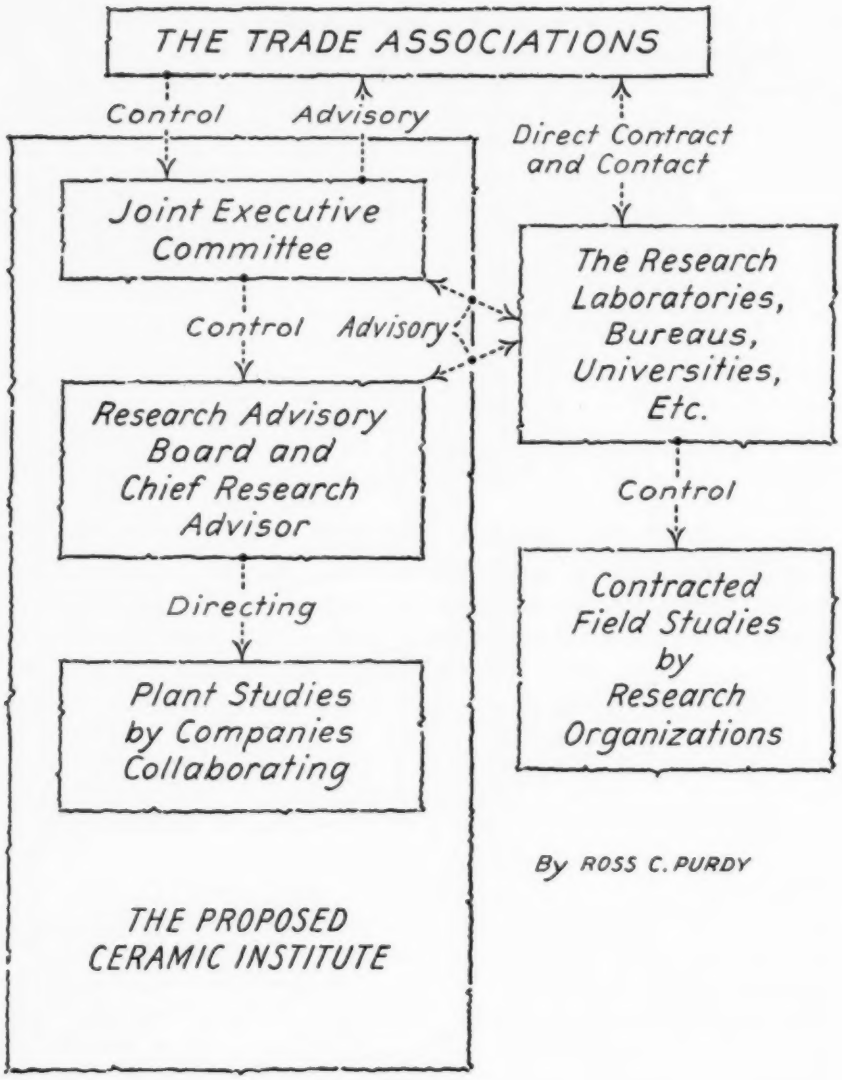


FIG. 1.

as are of immediate importance. All work on fundamentals is twofold, abstract and applied. There are enough problems of current need for which fundamental data are lacking that the federal bureau could well adopt as a working principle that all investigations should be carried through to proof under plant conditions.

The bureaus need a strong unit contact with the manufacturers in all ceramic investigation. The manufacturers should so organize as to make sure and readily available a strong working contact. All heavy clay products manufacturers would be placing themselves in position to give and to receive aid in federal researches if they would function through the Clay Products Institute. The whiteware manufacturers should organize a similar institute. Whether the trade associations having the same major problems will coöperate collectively through institutes or singly as trade associations, we are convinced that the means of collaboration diagrammed in the organization chart here shown will give the most flexible and yet the most positive and frictionless unit contact for the government.

As to allocation of ceramic work it will have to be admitted that for as long as the Bureau of Mines operates for the beneficiation of minerals, metallic and non-metallic, they will have to study fuel and metallurgical economies in which refractories have an important part. The Bureau of Mines will have to continue working in that borderland where the ceramic engineers, fuel engineers and metallurgical engineers have a great deal in common. If the ceramic work of Bureau of Mines was restricted to refractories for power and metallurgical purposes they would have a large burden. It would be well if they were so restricted.

The Bureau of Standards should do plant proving by sending men into the field. Plant proving involves considerable laboratory investigating and for this a station should be maintained. Quite naturally the geographic place for such a station is the industrial center of both ceramic producers and consumers. The Government has such a station in Columbus. Economies in operation from standpoint of the Government and the industries alike make evident that this Columbus station should be continued.

Also, the several state universities have extensive laboratory space, equipment and qualified research personnel with which the federal government and the industries should be coöperating. The largest and most far reaching consideration in this general question of allocation of ceramic work under federal and state auspices is in the economic employment of the facilities of the several state universities.

With a representative research advisory board as provided for in the scheme suggested in Fig. 1, the federal bureau would have the very broadest and best informed council and the industries would have the

benefit of the most economical employment of the country's research facilities. Economy, flexibility and best informed advisory service to the government and to the industries is made possible by the scheme here presented.

A LETTER FROM AN ACTIVE MEMBER

Why am I a member of the AMERICAN CERAMIC SOCIETY? Is it only to receive the monthly *Journal* and the other publications of the SOCIETY? I admit that these are worth more than the ten dollars annual dues, for in them are results of researches and operating schemes which represent a great many times $10.00 in original cost and many times $10.00 in value to me. Nowhere else can I find so complete an abstract of the world's ceramic literature. I realize that every cent over the office and postal expenses which the 2000 members pay as dues is put into the *Journal*, bibliographies and book lists. I know that the profit from these publications which comes directly from the information recorded, cataloged and transmitted equals several times the cash I give in exchange.

Though worth more than it costs, the *Journal* is not my fundamental reason for membership in the SOCIETY. The *Journal* is no more than a record of the results and not the cause of them. It is one of the essentials to the real purpose of the SOCIETY. Collaboration of the scientific, technical and artistic ceramists in promoting agencies for research and education for collecting and distributing information is the real purpose of the SOCIETY.

When I consider the profound change that has been made in the character of reading matter in the trade journals; when I contrast the present unfilled demand for men trained in ceramic schools with the very sparse opportunities for the school-trained men fifteen years ago; when I see trade associations placing high value on scientific and technical research; when I recall that the ceramic divisions in the federal bureaus were in response to petitions by this SOCIETY and when I learn that in every nation where the ceramic industries have developed there is a national organization like our AMERICAN CERAMIC SOCIETY, I feel proud that I have had a part in the work done by the members through the SOCIETY. I am sure that technical progress in ceramics in America has been possible because the scientific, technical and artistic ceramists have been working together, sharing information and exchanging experiences in an organized way. This is the reason I am a member of the AMERICAN CERAMIC SOCIETY.

PAPERS AND DISCUSSIONS

SILLIMANITE REFRACTORIES

By A. Malinovszky

The papers of Hewitt Wilson[1] and T. S. Curtis[2] which were read at the Summer Meeting of the American Ceramic Society at Los Angeles, California in regard to the fused sillimanite refractories were very interesting. As these researches were conducted only on electrically fused sillimanite ingots, I should like to know what percentage of glass has been found surrounding the crystals.

I have produced purer sillimanite crystals with much lower glass by the Bessemer method than with the electric furnace. The sillimanite crystals made in the electric furnace were not more than 75% or the highest 88% pure sillimanite. The rest was a glass which contained from 2% to 3% of $Na_2O + K_2O$ and from 1% to 2% of $CaO + MgO$.

Fig. 1.—The crystals as they occur in parallel blades. The ground glass which forms the base for the sillimanite crystals is made up of felty aggregates of very fine needles crossing every angle.

Prof. Salisbury who made the first petrographic examination in 1910 of the electrically fused sillimanite ingot called my attention to the fact that to produce pure sillimanite crystals I would have to first get rid of the alkalis before the crystallization process commences or use a purer material and coke.

Therefore, early in 1911 I had begun to experiment with the Bessemer method. This proved to be more satisfactory than the electric furnace.

With the Bessemer process I was able to eliminate the alkalis and I have produced a product of 95% pure sillimanite with only 5% of a ground glass free from the alkalis.

The Bessemer process gave a product which analyzed as high as 81% of Al_2O_3, especially those which were fused from diaspore or bauxite.

---

[1] H. Wilson, C. E. Sims and F. W. Schroeder, "Artificial Sillimanite as a Refractory," *Jour. Amer. Ceram. Soc.*, **7** [11], 842; [12], 907 (1924).

[2] T. S. Curtis, "Synthetic Sillimanite in Ceramic Bodies," *Jour. Amer. Ceram. Soc.*, **8** [1], 63–8(1925).

Professors Salisbury and Johannsen and also A. A. Klein and W. H. Tomlinson found corundum present ranging in the various samples from very small percentage up to as high as 16%. The higher the corundum the greater was the resistance to spalling, corrosion, load and high temperatures. Many samples of the sillimanite thus produced were more refractory than cone 42.

FIG. 2.—Enlarged about twenty diameters.

Of the three microphotos shown here, Fig. 1 contains 95% of sillimanite and 5% of a mixture of brown and clear glass. Figures 2 and 3 contain 90% of sillimanite and 10% of a mixture of brown, green and grayish white glass masses.

Figures 1 and 2 are sections parallel the fibers and Fig. 3, cross-section of the same ingot as Fig. 2.

In cross-section the sillimanite crystals are rather uniform in size ranging from .02 to .03 inch. It can be seen that these crystals are not solid but have a skeleton growth away from the centers toward the corners. In length the longest fiber measures over .35 inch and this was broken off at both ends. It is likely that many of the fibers are one inch or more in length.

FIG. 3.—Cross-section enlarged about twenty diameters.

There is no reason to suppose that the cost of super-refractories of sillimanite will prohibit its use commercially. At the Washington Iron Works a U. S. Rotary Smelter was lined with a sillimanite refractory a year ago and up to March this year has made 2416 smelts. First we smelted enamel and now we are smelting ground coat.

We lined the stationary smelters one year ago and in one have made 1600 smelts. It is still good for many more. In the other smelter we made only 600 smelts when we had to repair it. In the smelter which made only 600 smelts the brick perhaps contained a high percentage of glass high in alkalis which reduced its resistance to corrosion and spalling.

WASHINGTON IRON WORKS
LOS ANGELES, CALIF.

CHINA CLAY[1]

By Stephen Leech

In the course of contact with my fellow ceramists and others I have been struck by the lack of a precise understanding as to what china clay is, is not, and may be, more especially as to what constitutes the difference between the "imported" and the "domestic" (or as I should prefer to call it, the "native") china clay.

There is a fundamental difference between the two.

Broadly speaking, the "imported" or English china clay is the result of the kaolinization by pneumatolytic action on the feldspar of granite, the altered product remaining *in situ* until the moment of its artificial separation from the other elements of the granite (these remaining unaltered). The domestic or native china clays are the result of subatmospheric decomposition of rocks, chiefly of the gneissic order, at the surface, their kaolinitic matter being separated by aqueous influences, carried and redeposited elsewhere.

The effect physically and, possibly, chemically of these varying conditions is a matter well worthy of consideration. So far as I know there is no evidence of pneumatolytic action ever having taken place in this country, and although I do not regard the evidence on the point as being complete, I think it may be taken for granted that the native clays are the outcome of trituration and redeposition alone.

Our Earth

We have, therefore, first of all to take into consideration the English clays, in their primary form as part of granite.

If we were to get below what one of the jesters in chemistry has thought well to call the "half-mile crust" of the earth we should find that the crust is getting (or remaining) softer and softer, more inchoate, until it finally passes into the semi-liquid state called "magma." Nearer still to the earth's center we should probably find this magma, which comes to our minds as a substance of the consistency of molasses, becoming still more thinly liquid and finally passing into vapor and then into gas alone. We are concerned only with the magmatic condition. In this, partly by reason of physical and chemical affinities, are formed segregations of matter of different constitutions. They are probably irregularly disposed. One of these is the granite magma, that is, it is a magma containing silica, alumina, alkali or alkalis and some metallic elements in such proportions that if ejected to the surface the magma would cool as granite.

The older portion of the crust of the earth, as it cooled, contracted—forming cracks and fissures all over its surface. The detached portions

[1] Recd. January, 1925.

so formed sank and tilted at irregular angles, receding into the unsolidified magma below with a double effect—that of forming what are called "faults" (more or less vertical fissures) and of squeezing out through such fissures the underlying magma to the surface. Here the magma cooled. Its excess of silica crystallized out as quartz, its combined silica and alumina and alkalis as feldspar, its minor metallic elements as mica—chiefly muscovite and biotite, with some little hornblende. Thus the cooled magma became granite—a mosaic of crystals of quartz, feldspar and hornblende with here and there films and detached flaky crystals of mica.

Floating in the molasses-like mass of the magma were what are called phenocrysts, that is, crystals of feldspar, of varying size. The reason for the formation of these in the magma before ejection is a matter of rather deep inquiry. Suffice it to say that it is usually attributed to supersaturation of the magma with the element silica. The presence of the phenocrysts is a matter of some importance as we shall see later. Together with the more liquid portions of the magma they were ejected to the surface, floating along like chips of wood in a stream. The magma spread in sheets and masses, often infiltrating the joint-planes of the measures through which it passed, but in the main it formed hills and mounds above the higher levels of faulted measures at the surface.

Subsequently, owing to the shifting or the exhausting of the magma, gases followed on along the same lines of weakness. These gases consisted largely of boron and fluorine, the former picking up the iron and certain other elements and forming schorl-tourmaline, the fluorine robbing the feldspar of its silica and rendering its alkalis soluble. It is in this condition that we find the mineral called china clay rock from which the china clay is derived.

Devon and Cornwall, England

This sequence of geological and mineralogical occurrences took place only within a very limited area in England, entirely in the southwestern part of the country, in the counties of Devon and Cornwall. There is practically no production of china clay in the British Islands outside these areas. The productive capacity of areas themselves differs considerably, the extent and thoroughness of the kaolinization varying. The St. Austell area is by far the best. The area takes its name from that of the pleasant little town on its southern coastal border. The town in turn borrowed it from that of its protecting saint, St. Austin or Augustin. From the town northward the country rises steadily until reaching a height of over 1000 feet above sea-level at Hensbarrow Downs, some six miles from St. Austell, and this point may be considered as the center of the china clay activity.

The St. Austell area as a whole—that is the area in which granite,

kaolinized or unkaolinized, is at the surface—falls into a shape which may well be likened to that of half of a large pear, the flat side downward.

Its shape and contour, which is to be taken as the plan-line of the granite where it clears the county rock or "killas" as it is called (and which killas measures are the Meadfoot Shales of the Middle Devonian formation), includes both kaolinized and unkaolinized areas. These are sharply separated by a line of fault called the luxulyan fault. The kaolinized portion lies to the west of this fault and the unkaolinized portion to the east.

The shape and the occurrence of the high points, afford data for interesting speculation. The flow of phenocrysts follows closely the center line, on both sides the luxulyan fault. The granite nearer the edge of the mass is finer in texture, indeed approaches that of microgranite. Again, the minor faults or fissures, which by the way carry tin wolfram and copper ores, are ranged on the flanks of the pear-shaped mass approximating to its course or are distinctly at right angles to it. These fissures are precisely where one would expect a mass of that shape to crack on cooling. There is little room for doubt therefore that the St. Austell mass of granite is of the order of things known as a laccolith, that is, there is probably a deep-seated neck somewhere from which the whole mass spreads eastward. The depth or thickness of the mass is difficult of estimation but it is probable that the mass rests on the upper surface of the next formation succeeding downward, the Devonian, *viz:* the Silurian, but as the lower measures of the Devonian do not outcrop in the district their thickness cannot be estimated with any certainty.

There was, it may therefore be assumed, a mass of granite having a central core or backbone of phenocrystine or, as it is called, porphyritic granite dating from a core or neck somewhat to the south of the eastern end of the mass.

From such a point would flow the last of the magma, to be succeeded by gases and vapors. That such was the case is evidenced by the fact that at or near the point indicated occurs the variety of the St. Austell granite known as Cornish or china stone. This "stone" differs from the general mass of the granite in several important respects. One of the most important is that it shows the invasion of fluorine. Its quartz becomes of a purple tint and it carries topaz grains, topaz being a fluoride of alumina. The topaz occasionally appears as a separate mass and in such cases is usually accompanied by much schorl-tourmaline. The latter is a borosilicate and, therefore, indicates and justifies the view previously expressed that the subsequent kaolinization of the granite, or rather of the feldspar of the granite, was effected by the action of fluorine in the presence of boron. The beneficent effect of the latter was to carry the iron of the rock present originally as biotite into the insoluble

of the borosilicate. It is only reasonable to admit that there is some contention as to the precise nature and sequence of the processes by which the kaolinization of the feldspar has come about. There are not wanting those who contend that the process has been from the surface downward; and other most ingenious theories have been advanced. The pneumatolytic theory is, however, the one most generally accepted and to it the writer, who has had the advantage of living on the spot for several years, gives his unqualified adherence.

The principal points of evidence in its favor are:

(1) The fact that the kaolinization never appears at the surface. There is always a layer of disintegrated but not kaolinized granite from the surface downward. This layer of material, which is locally called "growan" may be from four to fourteen feet thick. In it, all the elements of the granite are present. It ends off abruptly. In sinking through it, practically one spadeful is in the "growan" and the next in the fully kaolinized china clay rock. This is of itself strong presumptive evidence of rising, heated gases ending their influence at a definite point of cooling.

(2) The deeper the pits are sunk in the kaolinized rock the more complete, absolute and unvarying does the kaolinization become. Pits have been sunk to a depth of 300 feet with the result that the deeper the sinking is the better the clay.

(3) In some cases the overlying killas measures are also kaolinized and always from contact with the erstwhile granite upward, never from the surface downward.

(4) The area of kaolinization is sharply divided by the luxulyan fault.

Practically no kaolinization extends to the east of it. Gases permeating the granite mass from the west eastward would find in the broken and ill-filled fissures of the fault abundant outlets. Their efficiency ended there. It is certain that had the influence been a superficial one it would have affected the granite equally on both sides the line of faulting. That there was a very free escape of boron at this point is evidenced by the densely studded rock called luxulyanite from a single block, or rather boulder, of which the sarcophagus enclosing the remains of the Duke of Wellington was made. The beauty of this rock lays in the stellate clusters of tourmaline with which it is packed, and the tourmaline, as we have noted before, is the borosilicate of iron, magnesia and alumina.

Those who are so far interested in the contra-theories as to kaolinization will find the whole subject traversed in the very excellent book on china clay and china stone written by Allan Howe of the English Geological Survey. The writer wishes to take advantage of this allusion to acknowledge his own indebtedness to that work, which treats exhaustively the subject of china clay not only in England but in all countries of the world.

English China Clay

The china clay rock as it lays in the earth or near its surface is of the consistency of half-set concrete. It is hygroscopic, that is to say it takes up and retains much water. It is very rare to find it in dry condition. This is fortunate, as most of the pits working on it are on the tops of hills or along ridges on the sides of bare, bald, treeless hills, and water plays a most important part in the separation of the actual china clay from the quartz, mica and schorl-tourmaline which accompany it.

The methods by which the actual china clay, the now kaolinized feldspar, is separated from the quartz and other waste matter have been so frequently described and illustrated that it is not necessary for the present writer to more than summarize them. They have especially been set forth in all detail in the work before referred to, Allan Howe's book, and it is to be regretted that certain recent dissertations on the subject, which are almost word-for-word repetitions of the matter of that book have appeared in the columns of a contemporary without the acknowledgment that was their due.

Anywhere westward of the luxulyan fault there is little difficulty in finding an area to yield china clay. Of course care has to be exercised, especially on the subject of water supply, and, naturally, as to means of communication with road and rail. A site being selected and "proved" by the sinking of trial pits, a pumping shaft is sunk at some little distance from what is expected will become the center of the pit. This shaft is followed by an *adit* or level driven from the bottom of the pumping shaft to the center of the pit and then by an upcast shaft; the level is connected with the surface of the pit. The surface is then stripped of the overlying "burden," generally the growan before described and a foot or two of poor upland soil. The overburden is always kept well back from the edge of the pit and a deep trench sunk to receive percolating surface water and prevent its entering the actual pit. As the actual pit increases in size it is most important that this keeping back of the overburden is well attended to. It is a heavy "cost" on the china clay obtained, especially in the early stages of opening of a pit of work, and neglect of it is often the cause of much of the discoloration in the china clay as we receive it. Water must now be conveyed in trenches or "launders" to the edge of the actual pit and there allowed to run over and down the sides of the excavation. This has the effect of breaking down the softish rock, assisted by manual operations, the water pouring down into the pit below a puddly mass of "sand" (as all but the actual clay is called) and clay water.

It flows toward the center to the top of the upcast shaft, but it is intercepted in its course by the "sand boxes," a simple but ingenious contrivance by which the stream is allowed to precipitate the coarsest of its sand. The clay water enters and fills the upcast shaft and level. At

the pumping shaft it is brought to the surface, a suspension of 10% to 15% clay together with all the finer sand and all the mica.

The greatest difficulty the clay worker has is to get rid of the mica. By passing the suspension successively through smaller pits and finally in a slowly moving stream over broad areas of slightly inclined surface, called "mica-drags," the whole of the undesirable matter is precipitated, but not without serious loss of clay as well. The purified suspension is received in settling pits where, after considerable time, the clay settles and the excess water is decanted off and reused; the now creamy suspension is passed on to the "tanks" where a much longer period of time is allowed for it to further settle and solidify about to the consistency of the familiar substance—lard.

In this condition it is conveyed to and deposited on the "drys" or drying floors, large areas of porous tile overlying heating flues. The clay is spread in a layer 6 to 10 inches thick, "nicked-up" as it dries, and so leaves the floor in the roughly cuboidal chunks so familiar to us on receipt of our supply of "imported clay." It is never dried to "bone dryness" inasmuch as, being hygroscopic, it would again pick up from the atmosphere 10% to 12½% of moisture. We, therefore, all buy it well knowing we are buying that minimum amount of water.

All these arrangements sound very simple—almost primitive. So they are, but they are effective, and with the exception of the waste of clay or its reduction to second and third qualities known as "micaclays," there is little room for improvement upon them from an economical point of view. As compared with the "sandwheel" methods employed on the clays of this county they are far more effective in getting rid of deleterious matter.

Little has been done in England to substitute mechanical treatment for the older method of levigation and precipitation pure and simple. A fairly common practice is the acidulation of the water in the banks to facilitate precipitation. On the other hand an attempt has been made by increasing the viscosity of the bank water by the addition of sodium silicate to retain the finer particles of clay in suspension longer and so, by separate decantation and filter-pressing of the upper suspension, to obtain a finer grade of clay for special purposes. The most radical improvements which have been made in the process have been the substitution of forcibly ejected streams of water from hose-nozzles directed against the face of clay-rock in place of the natural run of the conducted stream down its face, which newer method is known as "hydraulicking," and the introduction of the pipe-line system. Many of the older works were situated back in the hills, the transfer of the finished clay to rail or port involving miles of heavy haulage over difficult roads. As fortunately, the average gradient is toward the coast it has been possible to establish systems of pipe-lines, the ordinary 9- or 12-inch sewer pipe of this country,

conveying the suspension at the point at which it would ordinarily pass to the settling tanks on the "work" to tanks and "drys" located at points on the railways or at ports eight to ten miles distant from the actual clay pits. Thus a double saving has been effected, the cost of hauling fuel for drying to the works and that of hauling the dried clay to loading stations.

The only really revolutionary method introduced to the trade within the writer's knowledge was passing the whole of the clay-rock through rotary washers and the effluent treated in a series of centrifugal separators culminating in the "Gee" separator. This was followed by an equally rapid system of drying in a progressive tunnel-drier. It was possible for the clay mined in the early part of the day to be loaded the same day as finished clay. The prime object, however, was to obtain clay of far finer texture than the ordinary for use in certain industries under the exigencies of war-time conditions.

It is generally conceded that English china clay represents an aggregation of crystals of the mineral, kaolinite. Such crystals are sub-microscopic but their structure and habit is known. They are flat, hexagonal or rhomboidal forms, of a thinness so extreme as to be barely comprehensible in figures. Their habit is to form, by superimposition, masses or groups, still so minute as to be only just within the possibility of detection under the highest-powered microscope, of dendritic or branching growths or in piles and strings known as "rouleaux" or "vermiculae." This initial fact is important to the user. The plasticity of china clay, often annoyingly limited, can be considerably enhanced by protracted grinding which has the effect of breaking down the aggregates and increasing vastly the area of surface tension.

We have in such china clay a substance of quite uniform chemical constitution. We can, therefore, rely upon its presenting a uniform degree of refractoriness, in other words of its being pretty constant in point of shrinkage and freedom from fire influences calculated to produce warping. Such measure of uncertainty as there may be between one grade of imported china clay and another is due rather to the degree of thoroughness with which the elimination of the mica (in particular) has or has not been carried out. That, in plain words, means that the best clay is produced by the firms having the largest mica-drag areas.

The pneumatolytic action which locked up the original iron of the granite by converting the biotite schorl-tourmaline thereby gave us a practically iron-free material, for the schorl is the one substance which, thanks to its high specific gravity, is most easily gotten rid of in the sedimentation processes. In addition, if the clay has been produced in the areas in which the primary granite was of the porphyritic or phenocrystine order the relative proportions of both mica and tourmaline were low, therefore good color is assured.

A MONEY SAVING RECORD SYSTEM FOR CASTING SHOPS[1]

By L. L. Beeken

Some sort of systematic factory record keeping is necessary in every ceramic manufacturing plant. Factory records are an essential part of any cost accounting system and they are an equally vital element of an exact and complete technical or process data history.

It is most important that such records be not laboriously obtained, complicated or too costly—"the tail must not wag the dog."

The record system used at the Jeffery-Dewitt Insulator Company has been evolved to cover their particular conditions.

Operation of the whole record system requires the employment of (1) a timekeeper who is also a superintendent clerk; (2) a bookkeeper who does all costing and also keeps all the rest of the Company's accounts; (3) foremen and certain factory operators to do a small amount of clerical work each day; (4) the operation of a factory storeroom and its attendant.

MAINTENANCE LABOR

At Dept.....

Charge No.....Date.....

Job.....

.....

Hours.....Rate.....Amount.....

O. K. .....
Employee

.....
Dept. Foreman

.....Clock No.....

The system supplies the cost accounts with (1) all production counts; (2) all time or labor charges; (3) all material charges; (4) overhead or burden distribution; (5) inventories of raw materials, work in process and stock. At the same time it gives

DAILY TIME REPORT

Date.....2/9.....1925

Name.....Allen Keffer..... Clock No.....165.....

Account	Lot No.	No. Hours or Pieces	Rate	
1302		4½	.70	$3.15
801		1		.70
708		2½		1.75
	Total			

O. K.....V. P. Mengle.....
Foreman

Approved.....
Supt.

Recorded

.....
Time Book

.....
Cost Record

[1] Presented at the Annual Meeting, American Ceramic Society, Columbus, Ohio, Feb., 1925. (White Wares Division.)

us rather complete technical and process data upon each lot of each type of product; and does this systematically and automatically.

Three main classes of records are involved, namely (1) time or labor charges; (2) material requisitions; (3) lot production records.

Time or Labor Charges

The factory time or labor charge slips are similar to those in common use. Each workman daily charges his hours (or piece work) to the account worked upon. This is approved by the foreman and sent to the timekeeper, who in turn checks against clock cards, makes pay-roll entries and cost distribution. He accomplishes his entire timekeeper's work in about three hours.

MILLING REPORT

Lot No..... Body No..... Date.....

	Mill No.	Mill No.	Mill No.	Mill No.	Mill No.
Flint					
"					
"					
Feldspar					
"					
"					
"					
Clay					
"					
Water					
Viscosity					
Weight					
Temperature					
Screen Test					
Time Started					
Time Finished					
Revolutions					
Clay		BLUNGING			
"					
"					
"					
White Ware Scrap					
Glaze Scrap					
Sodjum Silicate					
Water					
Time Started					
Time Finished					

GLAZE MILL

	Mill No.	
Glaze No.		
No. of Pounds		
Time Started		
Time Finished		
Viscosity		
Temperature		
Weight		

STORAGE TANK

No. Feet of Slip in Tank	
Temperature	
Weight	
Viscosity	

EQUIPMENT INSPECTION

Mills	
Blungers	
Pumps	
Lawn	
Agitators	
Scrap Blungers	

MATERIAL STOCK WARNING:—

DELAYS AND REMARKS:—

Material Requisitions

The material requisitions give account of all material used. They are of two classes: (*a*) for production raw materials; (*b*) for maintenance or manufacturing supplies.

Class "A" Production of Raw Materials

Each batch of ceramic raw material withdrawn from bins is weighed and listed on a day sheet. These sheets go to the bookkeeper and are means of keeping perpetual inventories and of making material charge for month, from which the slip cost per month is obtained. Physical inventories of raw material in bins and slip in tanks are taken the first of each month and thus the perpetual inventory checked and corrected if need be. A similar system applies on all hardware and other production raw materials used in the plant.

Maintenance and Manufacturing Supplies

Maintenance and manufacturing supplies are kept in the factory storeroom. These materials can be withdrawn only through a storeroom requisition. The accounting of these materials is done then by the bookkeeper in the usual manner of storekeeping.

REQUISITION ON STOREROOM

.....Date.....Charge to.....

Quantity	ITEMS	Price	Amount

Received By	Approved By	Entered on Stock Record

Production Records

Lot Records

Our lot production records give us a really big return for the small effort they involve.

They prevent confusion in the shop; they give all counts and inventories of work in process; locate at any time the exact position in process, and status to date, of any production order; and they leave behind a permanent history of process conditions and technical data upon each order and lot of the order manufactured.

The need of such a system is evident. We manufacture sixteen different standard types of porcelain, as well as specials, when such orders are received, and the same molds, racks, forming machines and other equipment are used for several of these types. While our standardization of design and process does give great flexibility and does mean little or no idle equipment, it must be recognized that such conditions make systematic production planning and routing imperative.

Production Order Form

Before starting manufacture production each type and each order of porcelain is scheduled upon the production order form (see page 651):

Since it is necessary to see that these production schedules are maintained or if they are not to make process adjustment, a systematic accounting and knowledge of the location in process is demanded covering each production order. The lot production records perform this function.

The lot records originate from sheets filled in by each department foreman covering each lot on each production order that moves into and out of their department.

MAINTENANCE ACCOUNTS

MILLING AND GLAZE MAKING EQUIPMENT

101 Motors, Wiring, and Electrical Equipment
102 Line Shafting, Pulleys and Hangers
103 Clutches
104 Belting
105 #1 Mill
106 #2 Mill
107 #3 Mill
108 #4 Mill
109 #1 Blunger
110 #2 Blunger
111 #3 Blunger
112 #4 Blunger
113 Slip Pumps
114 Slip Lines and Valves
115 Slip Tanks and Agitators
116 Water Lines or Hose
117 Milling Room Trucks and Tools
118 Milling Room Office and Fixtures
119 Milling Room Scales
120 Scrap Blungers
121 Glaze Mills and Blunger
122 Glaze Pumps and Lines
123 Glaze Tanks and Agitators
124 Indicating and Recording Instruments
125 Distilled Water System
126 Testing Apparatus
127 Oils and Waste
128 Lawn
129 Clay Disintegrating Equipment

CASTING EQUIPMENT

201 Slip Working Tanks and Agitators
202 Slip Pouring Lines and Hose
203 Mold Racks or Stillyards
204 Steam Heating Coils, Lines, Regulators and Valves
206 Molds (including renovating)
207 Portable Racks and Rack Boards
208 Casting Room Tools
209 Casting Room Office and Fixtures
210 Indicating and Recording Instruments
211 Mold Renovating Equipment
212 Pouring Nozzles
213 Vacuum Casting Machine
205 Vacuum Return Lines and Traps

DRYING EQUIPMENT

301 Motors, Wiring and Electrical Equipment
302 Line Shafting, Hangers and Pulleys
303 Clutches
304 Belting
305 Fans
306 Steam Heating Coils, Lines, Regulators and Valves
307 Vacuum Return Lines and Traps
308 Humidity Steam Equipment
309 Indicating and Recording Instruments
310 Drier Structure
311 Drier Tools and Fixtures
312 Trucks
313 Control Weighing Equipment
314 Oils and Waste

FORMING AND GLAZING EQUIPMENT

401 Motors, Wiring and Electrical Equipment
402 Shafting, Hangers, Pulleys, Clutches
403 Belting
404 Facers
405 Groovers
406 Drills
407 Sponging Tables
408 Glazing Equipment
409 Dust Exhaust System
410 Forming Room Tools and Trucks
411 Forming Room Office and Fixtures
412 Pin Type Forming Equipment
413 Special Insulator Forming Equipment
414 Vacuum Lines and Equipment
415 Oils and Waste
416 Universal Drilling Machine
417 Universal Profiling Machine
418 Cutter Blades

KILNS AND KILN SETTING EQUIPMENT

501 #1 Kiln Cars and Car Brick Work
502 " Pusher and Track
503 " Exhaust Fans
504 " Water Cooling Equipment
505 " Indicating and Recording Instruments
506 " Kiln Structure
507 " Burners and Flame Shields
508 " Chains and Rollers
509 " Transfers and Gages
510
511
512 #2 Kiln Cars and Car Brick Work
513 " Pusher and Track
514 " Exhaust Fans
515 " Water Cooling Equipment
516 " Indicating and Recording Instruments
517 " Kiln Structure
518 " Burners and Flame Shields
519 " Transfers and Gages
520
521 Sagger Loading Equipment
522 Steam Pusher Engine
523 Car Hauling Equipment
524 Gas Lines, Regulators and Valves
525 Kiln Tools
526 Fixtures and Kiln Office
527 Vacuum Placing Equipment
528 Bitstone Screening Equipment
529 Oils and Waste

ASSEMBLY AND CRATING EQUIPMENT

601 Suspension Type Jigs
602 Heavy Flange Jigs
603 Alloy Pots and Equipment
604 Racks
605 Tools and Fixtures
606 Gas Lines
607 String Assembly and Crating Tables
608 Roof Type Assembly Equipment
609 Storage and Loading Docks
610 Assembly Department Office Fixtures
611 Storage Platforms

LABORATORIES AND INSPECTION EQUIPMENT

701 Ceramic Laboratory Apparatus
702 Electrical Laboratory Apparatus
705 Boxes
706 Fuchsine Equipment
707 Pull Test Machine
708 Oscillators
709 Tools and Fixtures
710 Scales
711 Trucks

SAGGERS AND WAD CLAY EQUIPMENT

801 Motors, Wiring, and Electrical Equipment
802 Shafting, Pulleys and Hangers
803 Belting
804 Clutches
805 Pug Mills
806 Press
807 Grog Mill and Housing
808 Grog Elevators
809 Racks
810 Drier Sagger
811 Clay Drier
812 Wheelbarrows and Tools
813 Oils and Waste
814 Pat Press

MOLD MAKING EQUIPMENT

901 Mold Shop and Equipment

GALVANIZING EQUIPMENT

1001 Rumbling Equipment
1002 Pickling Equipment
1003 Drilling and Emery Wheel Equipment
1004 Transmission Machinery
1005 Galvanizing Pots
1006 Indicating and Recording Instruments
1007 Electro Galvanizing Equipment
1008 Shaking and Quenching Equipment

GALVANIZING EQUIPMENT (CONTINUED)

1009 Exhauster Equipment
1010 Fixtures and Tools
1011 Hardware Boxes

STORAGE - MATERIALS AND SUPPLIES

1101 Clay Bins
1102 Hardware Bins
1103 General Storeroom Bins and Shelves
1104 Fixtures
1105 Equipment Shed
1106 Maintenance Store Sheds
1107 Yard Storage
1108 Elevators and Transporting Equipment
1109 Unloaders, Wheelbarrows and Shovels

MACHINE SHOP AND TOOLS

1201 Drill Presses and Power Saws
1202 Milling Machine and Shaper
1203 Lathes
1204 Grinders
1205 Tool Crib
1206 Bench and Bench Tools
1207 Carpenter Tools and Equipment
1208 Tinners Tools and Equipment
1209 Pipe Fitters Tools and Equipment
1210 Electricians Tools and Equipment
1211 Welders Tools and Equipment
1212 Blacksmith Tools and Equipment
1213 Wheel Dressing Equipment
1214 Concrete Mixer
1215 Oils and Waste

HEAT, LIGHT AND POWER EQUIPMENT

1301 General Steam Lines
1302 General Electric Meters and Wiring
1303 General Gas Meters and Piping
1304 Boilers
1305 Boiler Feed Apparatus
1306 Stacks
1307 Tools and Fixtures
1308 Electric Light Bulbs
1309 Pumps and Air Compressors
1310 Oils and Waste

FIRE, WATER AND SEWERAGE SYSTEM

1401 Sprinkler System
1402 Fire Hose and Extinguishers
1403 Water Storage Tanks
1404 General Water Lines
1405 Drinking Water System
1406 Factory Toilets
1407 Office Toilets
1408 Sewer Lines
1409 Chemical Tanks and Equipment
1410 Shower Baths

BUILDINGS, YARDS AND GROUNDS

1501 Roofs
1502 Building Structure
1503 Floors (All departments)
1504 Windows and Doors
1505 Ceramic (Back) Yard
1506 Side Yards
1507 Front Yards
1508 Roads and Walks
1509 Heating Equipment
1510 Garage
1513 General Painting

MAINTENANCE SALARIES

1601 Storeroom Keeper
1602 Watchmen
1603 Janitors
1604 Vacation Salaries
1605 Time Keeper

MISCELLANEOUS

1701 First Aid Equipment
1702 Miscellaneous Trucking
1703 Janitors Supplies
1704 Maintenance Inspection
1705 Miscellaneous Safety Work
1706 Lunch Tables
1707 Telecall System
1708 Office Fixtures

JEFFERY-DEWITT INSULATOR CO.

PRODUCTION ORDER NO.....

Type No.....Factory Order No.....Its Date of Issue.....

Purchaser.....

Number Finished Units Required.....Date Manufacture to be Complete.....

DESCRIPTION OF PRODUCT

Drawing No. of Mold Used..... Drawing No. of Cast Blank.....

Drawing No. of Formed Stage..... Drawing No. of Fired Stage.....

Drawing No. of Assembled Unit..... Physical and Electrical Specifications.....

Remarks: ....

....

....

PRODUCTION REQUIREMENTS

(1) To be made from Body No..... (2) Number Molds Required.....

(3) How Cast..... (4) Casting Space Required.....

(5) Forming Tools Req. Order No..... (6) Glaze Specified.....

(7) Firing Pats Required..... (8) Sagger Requirements:

Remarks: ..... Number Needed per Day.....

..... Type of Sagger.....

PRODUCTION SCHEDULE BY DEPARTMENTS

	DUE				ACCOMPLISHED				
					Date				
	Date order started	Date order finished	Number in lot or (per day)	Total No. expected this dept.	Order start	Order finish	Total No. finished this dept.	Lot numbers inclusive	Per cent loss
Molds									
Casting									
Drying									
Forming									
Kiln-Set									
Inspection									
Assembly									
Shipping									
Total									

Cost Sheet No..... Lot Numbers from.....to.....Inclusive

A Lot A lot is that number of units originated or cast each day for the particular type or production order. The production order sheets designate the number.

These lot records are used by each department foreman and are padded together.

One pad is entered with each lot started at the casting department. When the lot itself actually leaves the casting department (to enter the

CASTING

TYPE NO._____

Production Order No. _____ Lot No. _____ **1**

Number Cast _____

Date Cast _____ Date Removed _____

Number Good _____

JEFFERY-DEWITT INSULATOR COMPANY

CASTING PRACTISE

TYPE No. _____ P. O. No. _____ Lot No. _____

Date Lot Delivered _____

SLIP AT CASTING						DRY CONTROL WEIGHTS			
Tank	Viscosity	Temp.	Weight per Pint	Settle Ratio	Specific Gravity	Letter	Wt. Blank Into Dryer	Wt. Blank Dried	Avg. water to be removed lbs. / %

Age of slip when cast _____ Temp. _____

Hours Steam on empty molds _____

Hours insulators in molds _____ Age of molds _____

REMARKS:

Signed _____

GREENWARE DRYING

TYPE NO._____

Production Order No. _____ Lot No. _____ **2**

Number Received _____

Date Loaded _____ Date Removed _____

Total to Forming Room _____

DRYING PRACTISE

Date Lot Delivered to Wt. Control _____

_____

TYPE No. _____ P. O. No. _____ Lot No. _____

Date into air dry _____ Out _____ Hours in air dry _____

Average temp. in air dryer _____ Dry Bulb _____ Wet Bulb _____

Into Drier No. _____ Date In _____ Date Out _____

Run No. _____ Days in Drier _____

Wet Bulb _____ DRIER OPERATION Dry Bulb _____

JEFFERY-DEWITT INS. LATOR CO.

Hrs.	Temperatures 70	80	90	100	110	Weight of Blank					
12											
24											
36											
48											
60											
72											
84											
96											
108											
120											
132											
144											
160											

CONTROL WEIGHT

Number Overweights _____ %

Location Overweights _____

_____

Stillage, Weights—Dry _____

_____

FORMING AND GLAZING

TYPE NO._____

Production Order No. _____ Lot No. _____ **3**

Number Received _____ Delivered _____

Date Formed _____ Loaded _____

Delivered to Kiln Set _____

FORMING DEPARTMENT

Date delivered to Kiln Set _____

TYPE No. _____ P. O. No. _____ Lot No. _____

Glaze No. _____ Color _____

Moisture in Ware _____ Hub _____ Skirt _____

JEFFERY-DEW T INSULATOR

BEEKEN

CASTING DEPARTMENT

Air Holes	
Hub Holes	
Hub Cracks	
Groove Cracks	
Wire Cracks	
Boards off Racks	
Ceramic Lab. or Testing	
Hub off Side	
Spauled	
Pouring Cracks	
Mashed Down	
Plaster	
Floated Lids	
Bumped	
Total Charged Casting	

DRYING DEPARTMENT

Dryer Cracks	
Bumped in Dryer	
Dryer Testing	
Total Charged Drying	

FORMING DEPARTMENT

Groover	
Facer	
Belt Trouble	
Drill	
Glazer	
Bumped	
Total Charged Forming	
Total loss at Forming Insp. %	

Kiln Setting

TYPE NO._____

Production Order No._____ Lot No._____ **4**

Number Received_____ Delivered _____

Date Loaded _____

Kiln Setting Loss _____

No. Into Kiln No. 1_____ No. 2_____ No. 3_____

Total No. into all Kilns_____ Number Cast_____

Kiln Setting

TYPE No._____ P. O. No._____ Lot No._____

Moisture in ware, Hub_____ Skirt_____

Date Start Loading_____ Date Finish_____

Crew No.	Car No.	Amount on car	Crew No.	Car No.	Amount on car
KILN NO._____			KILN NO._____		
Total			Total		

JEFFERY-DEWITT INSULATOR CO.

Kiln Burning

TYPE NO._____

Production Order No._____ Lot No._____ **5**

Number Into Kiln_____ No. Unloaded_____

Date Unloaded_____

Total No. Underfire _____

Total No. O. K. for Visual Insp._____

Kiln Burning

TYPE No._____ P. O. No._____ Lot No._____

Date out Kiln_____ CONE CHART % underfire loss_____%

Kiln No._____				Kiln No._____				Kiln No._____			
Car	T	B		Car	T	B		Car	T	B	
			D				D				D
			H				H				H
			T				T				T
			D				D				D
			H				H				H
			T				T				T
			D				D				D
			H				H				H
			T				T				T
			D				D				D
			H				H				H
			T				T				T
			D				D				D
			H				H				H
			T				T				T
			D				D				D
			H				H				H
			T				T				T
			D				D				D
			H				H				H
			T				T				T
			D				D				D
			H				H				H
			T				T				T
OPTICAL READINGS											
Kiln No._____				Kiln No._____				Kiln No._____			
Position		Temp.		Position		Temp.		Position		Temp.	

JEFFERY-DEWITT INSULATOR CO.

TYPE NO._____

Porcelain Inspection

Production Order No._____ Lot_____ **6**

Total No. O. K. Fuchsine for Inspection_____

Number Rejected at Inspection _____

Total Number Accepted _____

Date Inspection Complete _____

Porcelain Inspection

TYPE No._____ P. O. No._____ Lot No._____

Date Inspection: Start_____ Finish_____

VISUAL INSPECTION

	Kiln No._____	Kiln No._____	Total
Lower Hub			
Upper Hub			
Shoulder			
Groove			
Skirt			
Handling Chip			
Kiln Chip			
Sandy			
Overfire			
Total			

TESTING

Results of Puncture Test	Test	Results Tensil Test
	1	
	2	
	3	
	4	
	5	
	6	
	Total	
	Aver.	

JEFFERY-DEWITT INSULATOR

BEEKEN

drying department) the casting department sheet, now filled in, is torn off and sent to the superintendent's office and the rest of the pad goes with the ware to the drying department. And so, throughout the process, the pad goes with the ware and the filled-in sheets are torn off and sent to the superintendent's office. However, since the sheets are padded in duplicate each department keeps a copy of this record.

These record sheets are now to serve at the superintendent's office several uses: (1) a tally against the schedule called for on the production order; (2) to supply the counts of ware in process and to give the location of each lot in process; (3) to give the perpetual inventory figures for wares in process and stock; (4) to give the process data covering technical information.

Each sheet is perforated. The upper part is used for the count, inventory and position records. These slips have certain data recorded on the count charts at the superintendent's office.

Then the slips themselves are put into the count tally board. This board files all slips coming to the office for the month. Reference really determines just where each lot is in actual factory position, how much of any order is filled and when it will be completed. You will note that the processing data covering each lot found on the main part of each lot record is pretty complete.

There are established standard process conditions. With these records we can compare actual against standard at a glance. That such is a manufacturing help is obvious.

These slips are filed in small loose leaf books.

A set of books for each type of porcelain and a book for each department are given. Thus, we have a live, up-to-the-minute ready reference library on production and process.

However, we believe in charts and curves. We feel that the general trends and their resultants are best shown in this way, so vital elements of data are plotted on charts and the trends watched. These charts we find most valuable in settling matters of what is right and wrong practice, and they give us opportunity of getting exact knowledge of technical matter that we have gotten in no other way. Charts allow us to plot losses against process conditions.

Finally, we have a sheet that assembles all this process and account record.

These sheets are readily filed in loose leaf books by types and form a final or historic record. This last record is not used as frequently as the others perhaps, yet, when wanted quickly, particularly for history, is useful enough to warrant keeping it.

It should be realized that in our case all types and lot of production go through the same flow, that is, each have the same route through the

LOT PRODUCTION REPORT

Lot No.....

Date Cast.....

MILLING

Body No.....

Residue on 300 Mesh Screen One Pint of Slip.....

Lbs. Sodium Silicate per Mill.....

CASTING

Properties of Slip

Temperature.....Viscosity.....Weight.....

Time of Casting by Lab. Test.....

Age of Slip When Cast.....

Hours Steam on Empty Molds.....Temp.....

Hours Insulators in Molds.....Age of Molds.....

% Casting Loss Reported by Forming Department.....

GREENWARE DRYING

Date into Air Dry.....Date Weighed.....

Average Temp. in Air Drier....Dry Bulb.....Wet Bulb.....

Date into Drier No.....Date Fan Off.....

Max. Weights as Follows:

Stillage.....

Weight.....

% Overweight.....

% Drier Loss Reported from Forming Department.....

Strength of Green, Dry Body Modulus of Rupture by Lab. Test.....

FORMING

Date Formed.....

% Forming Loss (Machines).....

Glaze No.....

Moisture in Ware Passing Weight of Inspection

Hub.....Skirt.....

Moisture in Redried Ware

Hub.....Skirt.....

PROCESSING:

Groover.....

Facer.....

Drill.....

Sponging.....

Palleting.....

Glazing.....

GLAZE DRYING AND KILN SETTING

Date into Air Dry.....

Date into Drier No.....

Date O. K. to Set.....

Date Inspected.....

Moisture When Inspected

Hub.....Skirt.....

FIRING

Kiln No.....Date in.....

Date out.....

% Under Fire Loss.....

% Over Fire Loss.....

Average Cone Bottom Sagger.....

No. Cast	
Loss	
% Loss	
No. Received	
Loss	
% Loss	
No. Worked	
Casting Losses	
Drying	
Forming	
Total	
% Loss	
No. Glazed	
No. Inspected	
Loss	
% Loss	
No. Loaded	
Kiln Loss	
% Loss	

VISUAL INSPECTION Per Cent Loss as Follows:		
Lower Hub	No. Inspected	
Upper Hub	No. Rejected	
Shoulder	% Loss	
Groove	No. Accepted	
Skirt	% Accepted	
Misc.	Of No. Cast	
Total		

FINAL INSPECTION AND TESTING

Note any Unusual Loss.....

.....

.....

Tensile Strength of Units Given Puncture Test.....

Results of Puncture Test.....

STATION INDEX REPORT

Losses	Dried Blanks	Blanks Grooved and Faced	Completely Formed Unglazed
Lower Hub			
Upper Hub			
Shoulder			
Skirt			
Misc.			
Total			

plant. Again in our case all porcelains are made from the same slip. The milling room, in our sense, precedes the start of manufacture, it supplies a raw material and only the one standard slip. This means, too, in our accounting department the slip room sells the slip by the pound to the rest of the process. Thus, the material costing is simplified. Then, too, in like manner, finished, fired and accepted porcelains only are sold the insulator assembly division and likewise by such a conception is accounting and recording simplified.

Jeffery-Dewitt Insulator Co.
Kenova, W. Va.

Discussion

E. H. Fritz: Do you keep that record only on your one standard style of insulator, or all styles?

W. K. McAfee: All styles of insulators have the form he has shown you there.

E. H. Fritz: Will there be more than one style made in one day?

P. H. Sanborn: Yes, there may be as many as ten different ones being made in a day and each one will have that same system to go through.

E. H. FRITZ: That would be a maximum?

P. H. SANBORN: It probably would be.

E. H. FRITZ: If you are making a greater variety of styles the system is more difficult to make use of and takes more time to keep up.

R. E. ELLIOTT: We keep similar records in our factory daily of the production of every department, but we have found it not to be of any advantage to compile the cost figures monthly. We did start doing that but we found that by taking the longer period it gives us a much better result and gives all the information required as far as actual cost figures are concerned, but so far as production and loss figures are concerned the shorter period might be the better as a protection.

The paper, of course, being applied to electrical porcelain, did not bring out some points which apply particularly to sanitary ware. For instance, in figuring the cost of the sanitary piece we base our cost on the cubical content in the kiln. That was a point which was not brought out. I do not know whether that applies to most factories or not, but we found it a very satisfactory method.

W. K. MCAFEE: Do you mean in distributing the overhead or burden?

R. E. ELLIOTT: Yes, and even in distributing the operating expenses because after all those little pieces cost exactly in proportion to the space they occupy in the kiln.

W. K. MCAFEE: There are other factors that enter into that. It is conceivable that some pieces take relatively more space in the casting than they do in the kiln due to complicated molds, etc. That is, they should get a comparatively higher percentage of the casting shop overhead than they should of the kiln overhead.

R. E. ELLIOTT: We have discovered that it is hardly worth our while to differentiate between a lot of different items of overhead. As a matter of fact, we have a general overhead expense, and if we distribute it into one portion we get about all the information we need. We could subdivide it but I do not think the information amounts to very much. After all, we have a general overhead expense to add to a piece and if we apply it in a certain ratio we are getting about the same results.

F. S. HUNT: My experience in distributing overhead and various expenses is that we have to analyze the particular plant to which we are applying the system. It is very seldom that different plants will have the same conditions or the same problems. It is true that sanitary men have all the same problems or porcelain men or semi-vitreous or insulator men, but when we pass from one to the other we find an entirely different proposition and have to solve it in its own particular way.

PROPER SIZING OF MATERIALS FOR BRICK

By F. P. Nickerson

When referring to the sizing of material for brick, quite frequently we have in mind the size of the largest particles present and have a rather hazy conception of what goes to make up the balance of the structure.

In years gone by, the manufacturer would select a sizing or a limitation to the size of the largest particles that should be permitted in his product, and quite frequently that selection would be controlled by the effect those particles would have on the appearance of his product. He would attribute any other grievance that might be encountered in the process of manufacture to any and everything else from the clay pit or mine to the railroad car, and disregard the sizing of everything except the largest particles that should enter the mix.

I can recall when it was no uncommon thing for the paving brick salesman to point with pride to the uniform, fine grained texture of his brick when trying to interest some councilman or commissioner and assume a quality factor because of that fineness. Quite frequently that grain and texture was such as to produce a very high grade brick owing to the fact that the clay or shale and the disintegrating units and the screening or classifying equipment all happened to so fit the other requirements that a tolerably good proportioning of the many sized particles resulted.

His competitor may have had a material that did not so readily lend itself to the production of this fine grained, nicely finished product without encountering troubles that would be more grievous than the absence of a fine grain. In an endeavor to produce a fine grain and smooth finish product he would suffer losses from body ruptures, surface checks or cracks, ghastly lines of lamination or an uneven shrinkage and quite often blisters on the face of his brick. The available clay or shale, the machines that are doing the grinding and the machinery for classifying materials according to size (the screen) failed to harmonize; thus a fine grained product could only be obtained by taxing some other factor of quality.

Not all of the troublesome effects that I have mentioned are caused solely by improper sizing, but sizing (not only the size of the largest particles present, but all of the sizes that enter into the construction of a brick) has an influence that cannot be ignored.

Designing a Brick

For the sake of illustrating some of the points that have come to my attention I would like to use the term "design," meaning that we shall build a brick, not just miscellaneously out of a material that will pass through one given sized opening, but that we shall keep in touch with the various sizes that go to make up the aggregate of the brick.

We shall take a quantity of shale and clay and put it through the ordi-

nary process of disintegration and from that disintegrated mass classify or separate as to size and make five classifications of the results of the operation. Let us elect that the largest particle admissible to this aggregate shall not exceed $^1/_8$ inch in diameter; therefore after passing it through a $^1/_8$-inch opening the residue or first classification shall be excluded from the mix and be returned for further grinding.

Next, let us take from the material that has passed through the $^1/_8$-inch opening and pass as much as will go through a $^1/_{16}$-inch opening. The diameter of the largest particle that passes through the $^1/_{16}$-inch opening will be half that of the largest particle that passes through the $^1/_8$-inch opening. Again pass what will of the $^1/_{16}$-inch product through a $^1/_{32}$-inch opening and the product of the $^1/_{32}$-inch opening through a $^1/_{64}$-inch opening. This will give four classifications of sized particles out of which a brick is to be constructed having eliminated the first classification by reconsigning it to the grinding unit.

At the point of each separation after the first one the largest sized particle is just half the diameter of the largest particle present in the preceding classification, approximately one-eighth the volume and twice the area in ratio to volume.

The total area of each particle must be moistened with a film of water to stick it fast to its neighbors. The smaller the particle the nearer the volume of water carried becomes equal to the volume of the particle.

There is a limit to the quantity of these little particles that will be allowable, irrespective of the size of the largest particle admitted. Ignition loss must follow, water must again be eliminated and the little bonds that have been made will be strained and if there is not a sufficient number of the big brothers and half-grown brothers and intermediate ones so they can reach each other's hands without straining too hard, there will be a break in the family tie of that brick.

I have one case particularly in mind where paving brick are made. The material is an open bank shale, not uniform in hardness, covered with a blanket of surface clay varying in thickness from two to ten feet. Originally, the operation was such that there was a wide variation in the sizings that went into the brick, except that all of the product went through a certain kind of an opening. The size of the largest particle admitted into the brick from time to time was fairly uniform except as influenced by the difference in the character of the material striking against the opening. There was just as wide a variation in the results obtained in the abrasion tests as there was in the sizings that went into the brick. Any one familiar with this trouble knows what that means. It is a very unhappy state of events to have the abrasion loss run 25% when the specifications of the job are limited to 22%. The fact that one test out of three might have run 16% does not compensate for the one that goes 25%.

A total average of the screen analyses made on the operation showed that one-half of 1% was larger than $^1/_8$ inch in diameter, that 12% was $^1/_8$ inch and smaller, but larger than $^1/_{16}$ inch in diameter, that 25.8% was between $^1/_{32}$ inch and $^1/_{16}$ inch in diameter, 17% was between $^1/_{64}$ inch and $^1/_{32}$ inch in diameter and that the remaining 34.7% was smaller than $^1/_{64}$ inch in diameter. This mixture made a fairly good brick and passed the requirements of rattler specifications. Frequently when the material was damp and the various units of disintegration and classification were not delivering efficiently, the size of the largest particles changed 10% or 15% and the rattler loss increased.

They finally changed their screening operation so as to more nearly control the sizing and struck an average as follows: All passed $^1/_8$-inch opening. 25% stayed on the $^1/_{16}$-inch opening, 27% on the $^1/_{32}$-inch opening, 19% on the $^1/_{64}$-inch opening and the remaining 29% passing the $^1/_{64}$-inch opening.

Screen analyses were made for a period of five months, and rattler tests were made from various parts of the kiln. The screen analyses were surprisingly uniform and the rattler tests did not vary over three points from the average and the most of them went within $1^1/_2$%. The total average rattler loss was reduced more than 3%. At no time have they since run above the specification requirements for road construction.

On comparing a large number of screen analyses with the product results I have found that the controlling of the proportion of the sizings has a direct bearing on quality and uniformity.

Probably the exact proportion of the sizings that will make the best brick out of a variety of clays, will vary with each variety of clay. I am impressed with the belief that there is a proper proportion of the various sizings or sizes that will make from any given clay the best brick.

A comparison of screen analyses with the fired product shows that controlling the proportion of the various sizes has a direct bearing on quality and uniformity.

Evidently there is a proper proportion of the various sizes that will make the best brick from any given clay, but the proportioning will be different for each variety of clay that is employed.

W. S. Tyler Co.
Cleveland, Ohio

PLANT PLANNING

By T. W. Garve

ABSTRACT

A guide for plant planning is given concluded with flow sheets for heavy clay products from characteristic clays.

So many factors are involved in plant planning that it seems desirable to set down the essentials. This we have done in form of a schedule with accompanying brief discussions. Such a schedule can be varied to suit any particular case.

1. Sanitation and Safety

(a) Light, Ventilation and Heating; (b) General Cleanliness; (c) Dust Elimination by Fan Suction

No one can question the importance of these items. Architects and engineers provide for them, but too often their plans are not carried out. A factory where poor light and bad air, where dirt, grease, junk and dust are everywhere in evidence will always have a large labor turn-over and a low morale. The cost for providing these items is small but great is their value.

Avoid small courts and dark corners where dirt can easily accumulate. If shelves are used, they should be open and large and be placed where there is abundance of light, this being an essential not alone for cleanliness but also for fire protection.

A room or separate building should be provided with lockers for the men, with toilets and even showers.

Dust producing machinery should be boxed in and connected by piping to a dust arresting box and fan to eliminate the dust.

(d) Safety Appliances

This includes gear and belt guards on all machines, headroom in passages and stairways, hand railing for all platforms and stairs and the necessary fire protection. The distance from center railroad track to retaining wall or any building is not less now than eight feet.

2. Simplicity

(a) Routing Laterally

The routing should be as short as possible without necessarily being in a straight line. A U-shaped plan often works out to greater advantage and greater simplicity than a straight line, if light and ventilation are not sacrificed. The plant will thus be a more concentrated unit, allowing of better accessibility and inspection, and shortening the distance of empty return cars. It is always the same problem: that the product of time, mass (tonnage) and distance, equal to work, be a minimum.

(b) Routing Vertically It is best, if possible, to resort to initial elevation of the raw materials and gravity in the subsequent steps. Elevators often are full of trouble, conveyors less so but not immune. One should endeavor to eliminate elevators and conveyors as far as possible, but, where they are unavoidable it is essential that they be of ample capacity, the right type and properly installed with ample working space around the head and tail pulley equipment. If the losses in clayworking factories, directly traceable to elevators and conveyors, could be tabulated and presented to clayworkers, greater attention would be given to this secondary equipment.

(c) Buildings While it is costly to build strictly fire-proof it will pay in the long run. For clayworking plants the so-called "slow burning mill type" is often the most adaptable. While appearance is in favor of steel, it, if unprotected, is less fire resisting than heavy timber. Avoid narrow joists and rafters.

The buildings should be simple in design and roomy even though there may be some waste of space in favor of directness and simplicity.

(d) Machinery and Machine Settings Provide for substantial machinery without vibrations and of ample capacity. The horse power should be determined as accurately as possible if individual electric motors are to be used. The selection of proper machinery is a concomitant of experience, judgment and a knowledge of the raw materials and difficulties of the wares to be produced, and hence cannot be taken up here.

The clayworker should work out his own foundation plans, regardless of plans submitted, to be sure of later accessibility, of simplicity and rigidity.

Too many factories are built along the line of "solving that problem when we come to it" and not only show it but the manager apologizes for the mistakes "we made" in laying out the plant. Only by solving every conceivable contingency in the original plans can final plant simplicity be obtained.

3. Continuity

(a) Clay Storage Shall raw clay or ground clay be stored? Where the clay pit is accessible, and unfrozen or undrowned clay is available all year, a raw clay storage is not a necessity and the crushed and ground storage facilities within the factory will suffice to take care of small irregularities of the pit or transportation equipment. Clay under ground is always dry and never frozen and underground mining does not as a rule require raw clay storage.

Clay storage gives a better mixture. Crushed as well as ground clay should be stored to insure continuity of operation in case of a temporary breakdown of a crusher, pan, elevator, etc.

(b) Repairs and Facilities for Such Investigate all machinery in regard to the manner in which repairs have to be made, and keep this point always in view while planning settings and installations. Order duplicates of wearing parts at the very beginning.

4. Economy

(a) Clay Winning How? Pick and shovel; team scrapers and clay gatherers; steam, electric or gasoline driven shovels; drag line scraper; ditchers; shale planer; which? It is a problem for careful investigation of the material and thorough study of the problem of winning.

(b) Arrangement The subsequent steps in manufacture of the different units should follow each other in proper order eliminating conveying machinery and rehandling to a minimum, all to be efficiently arranged between the terminals of the incoming clay and the outgoing ware. Work out flow sheets (see later) and preliminary layouts.

(c) Waste Clay Equipment It should be automatic and out of the way. It can be underground or overhead or both as works out best. Chutes, conveyors, elevators, tracks, or overhead monorail can be used. It is a money saver if so constructed that it is no hindrance to the operations.

(d) Feeding Devices Crushers, grinding mills, dry pans, pug mills, etc. should be preceded by suitable feeders, the reciprocating type for coarse and the rotating type for fine material. Rotary mills for fine grinding are usually provided with feeders.

(e) Drives Silent chain will permit of short distances but it requires very exact setting and substantial foundation without the least vibrations. Belt drives should be as horizontal as possible with under pull, of ample width. Machine gears should be of steel.

(f) Coal Handling Coal should be distributed mechanically to save labor. It can be taken from overhead pockets of the railroad trestle and transported to the kilns by gasoline dump tractor or otherwise. It depends much upon conditions but it should not be overlooked since coal is a great item in most clay working plants.

5. Future Extension and Alterations

(*a*) Clay supply
(*b*) Property
(*c*) Plant arrangement
(*d*) Transportation facilities.

In order to get a general preliminary idea in regard to the arrangement

of the plant, it is advisable to draw or write up flow sheets from which the general plant layout later will be developed.

In the following we are giving eight flow sheets of characteristic clays for the planning of heavy clay product plants.

FLOW SHEET

1. MATERIAL
Soft or wet alluvial clay
Surface clay, plastic

PRODUCT
Common brick
Face brick
Drain tile
Hollow tile

Screw Feeder
Disintegrator
Rolls
Pug Mill
Auger Machine
Cutter
Off Bearing
Drier
Kilns

2. MATERIAL
Short or sandy surface clay

PRODUCT
Common brick
(Soft mud process)

Rolls or Disintegrator
Automatic Soft Mud Brick Machine
Cable Conveyor or Rack Cars
Drier
Kilns

3. MATERIAL
Glacial clay containing gravel, sand and pebbles

PRODUCT
Common brick
Face brick
Drain tile
Hollow tile

Granulator or Screw Feeder[1]
Rotary Drier

Storage Hopper	Storage Hopper
Disc Feeder	Disc Feeder
Dry Pan	Dry Pan
Elevator	Elevator
Screen	Screen

Storage Bins
Disc Feeder
Pug Mill
Auger Machine
Cutter
Off Bearing
Drier
Kilns

[1] The granulator for lumpy clay and the screw feeder for ordinary clays.

Flow Sheet

4. Material: Extremely plastic clay

Product: Common brick, Face brick, Drain tile, Hollow tile

The Clay: Storage Hopper → Screw Feeder → Disintegrator → Rolls

The Grog: Jaw Crusher → Dry Pan → Elevator → Bin → Disc Feeder

→ Pug Mill → Auger Machine → Cutter → Off Bearing → Drier → Kilns

5. Material: Shale and No. 2 Fire Clay

Product: Face brick (Dry Press Process)

Storage Hopper → Plate Feeder → Single Roll Crusher → Storage Bins → Plate Feeder → Dry Pan → Elevator → Screen (coarse) → Steamer → Storage Bins → Conveyor → Elevator → Storage Bin → Spiral or Screw Conveyor

→ Dry Pan (or Pulverizer) → Elevator → Screen → Mixer = (Press Feeder) → Press

→ Dry Pan (or Pulverizer) → Elevator → Screen → Mixer = (Press Feeder) → Press

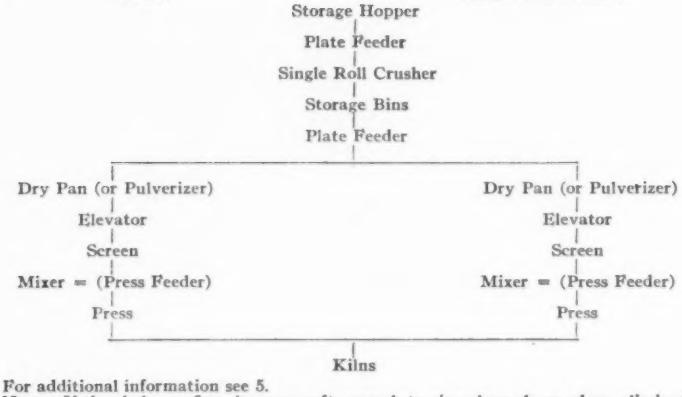
→ Kilns

Note: Steamer is merely to soften the clay. Additional water added in final pan.
Note: If clays are soft enough to give clean sharp edges, use flow sheet 5a.

Flow Sheet

5a. Material: Shale and No. 2 Fire Clay (Soft)

Product: Face brick (Dry Press Process)



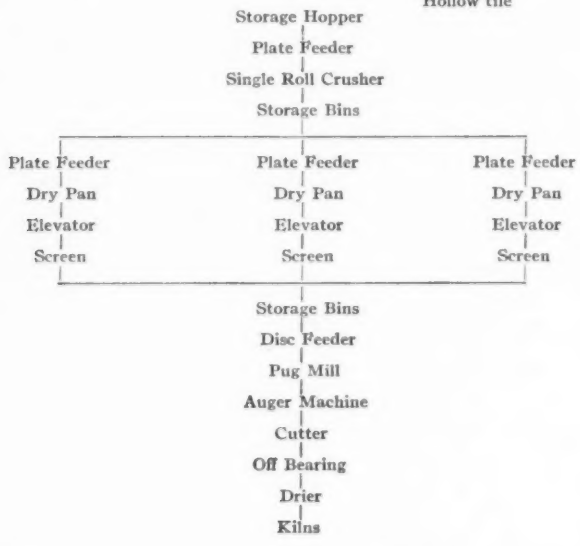
For additional information see 5.

Note: If the shales or fire clays are soft enough to give clean sharp edges, eliminate the steamer and the final pan or pans.

The remodeled plant at Shawnee, Ohio, had: "dry pan, screen, steamer, storage, conveyor, elevator, coarse screen for removing foreign matter, mixers, presses. This did fairly well for flashed iron-spot brick but would not make a high-grade face brick, set faced," says Richardson.

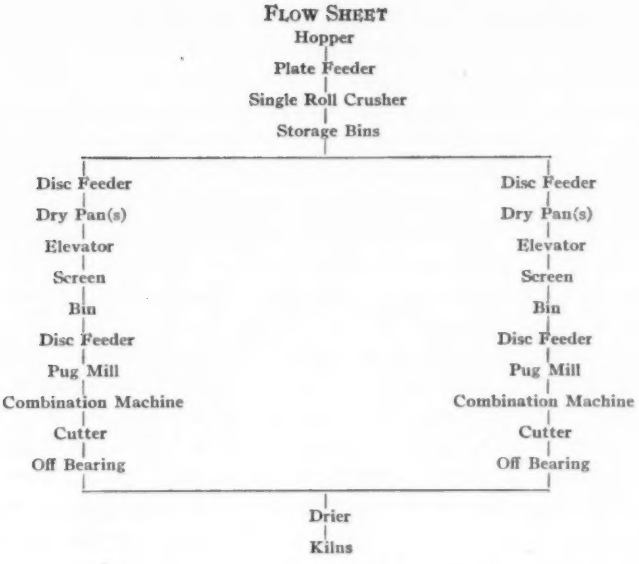
6. Material: Hard friable shale

Product: Face brick, Paving brick, Hollow tile



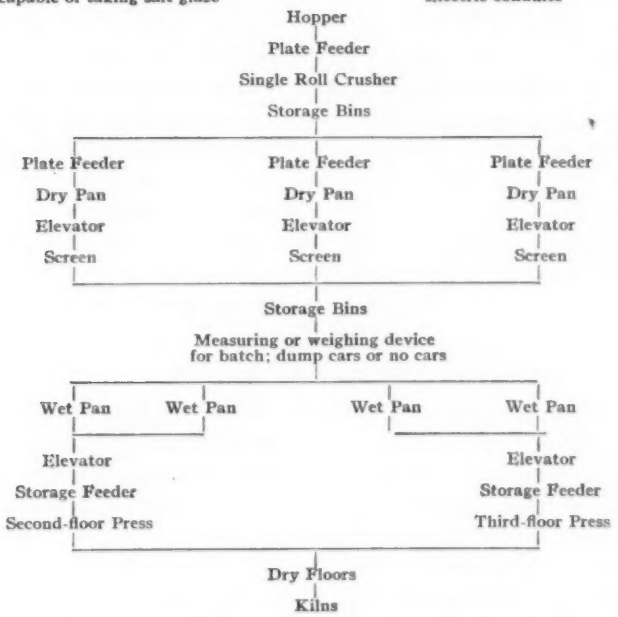
7. Material: Low refractory plastic fire clay; Shale of good plasticity and (high) mechanical strength, capable of taking good salt glaze for conduits

Product: Face brick, Hollow ware, Fire proofing, Electric conduits



8. MATERIAL
Shale, plastic and strong capable of taking salt glaze

PRODUCT
Sewer pipe
Electric conduits



Acknowledgment is due Mr. Lovejoy for going over the paper and many helpful suggestions.

ECONOMICS OF THE CAR TUNNEL KILN

By John L. Carruthers

ABSTRACT

The advantages of the car tunnel kiln over the periodic kiln claimed by different designers are reviewed. The installation of a car tunnel kiln from an investment standpoint is discussed. Consideration of factory layout, capacity, nature of raw materials and the characteristics of the ware to be fired is essential in planning a tunnel kiln installation. The economic features of tunnel kilns to be investigated before buying are discussed, as are also the problems that may arise in a factory incident to the installation of this type of kiln.

Introduction

The car tunnel kiln is today an accepted piece of equipment in the clay products industry. The kiln is not yet ideal or perfect, as there are improvements and refinements constantly being made in both design and application. It can be safely said, however, that the tunnel kiln has now passed through the experimental and development phase of its existence and is being generally recognized as a necessary "device" or "piece of equipment" in the scheme of economical production of the modern clay products factory. Also in the next ten years there can hardly be the advancement made in tunnel kiln design that the last five years has brought forth.

The *Journal of the American Ceramic Society* and trade periodicals have published at various times technical articles in regard to the tunnel kiln. These articles have, as a rule, dealt with operating data and results of certain tunnel kiln installations as compared to previous practice, the advantages and disadvantages of the different types of car tunnel kilns, the possibility and application of the tunnel kiln to certain industries and other interesting items. However, there is little, if any, literature that describes which features and qualifications of the car tunnel kiln should be investigated by a manufacturer considering the purchase of such a kiln; therefore, it is the purpose of the author to present his views in this direction.

Advantages of the Tunnel Kiln

Advocates of the car tunnel kiln claim that certain advantages are to be obtained through its use when compared with the prevalent practice of periodic kiln firing. It is well to know what claims are made by designers before starting an investigation. In the following paragraphs, all claims that the writer has known to be made by different designers in behalf of the car tunnel kiln are discussed, except those with which design is concerned. It is realized that arguments "pro and con" can be made on these claims, but such is not the purpose of this paper. No attempt is made to assign relative values to any of the advantages. These claimed advantages are as follows:

A higher percentage of No. 1 quality ware will be produced by the tunnel kiln because of the more uniform treatment that the clay ware received during the firing process. There is greater uniformity in the application of the heat used. The time-temperature element and the composition of combustion gases are under finer control. Also the distribution and amount of heat throughout the ware setting and the cooling process are more uniform in tunnel kiln action. The use of small settings eliminates losses quite prevalent in periodic kilns, due to the excessive loads carried by the lower pieces of the setting.

Low cost of maintenance is claimed for the tunnel kiln, because the masonry structure is not subjected to the destructive forces of expansion and contraction because of the methods used in applying heat to the ware.

Large fuel saving is a paramount advantage of the tunnel kiln. It is claimed that this saving will be from 40% to 85% per unit of ware as compared with periodic kilns. Regenerative and recuperative methods of heat recovery, together with a well insulated kiln structure, are fundamental in securing such savings.

Reduction of kiln labor costs (placing, firing and drawing) per unit of ware, in connection with tunnel kiln operation, is another advantage claimed. This reduction is attributed to the centralization of the loading and drawing of ware from the kiln, the comparatively small setting units and the better factory layout and production control, which are part of a well designed tunnel kiln installation.

The time required for firing and cooling ware in a tunnel kiln is less than when periodic kilns are used. The period of heat treatment necessary for any ceramic body is dependent upon mass, temperature and the physical and chemical characteristics of that body. In the tunnel kiln, small masses of ware are treated almost as individual units and can be fired in less time with perhaps a slight increase in temperature necessary to balance the operation.

This saving of time is valuable to a manufacturer, in that it decreases to a considerable degree the actual time required to change the raw material into finished product and thus give more rapid turnover of capital invested in material in process.

A tunnel kiln in a factory acts as a pace-maker for the entire organization. The kiln operation is set to a time schedule, consequently all departments must set their speed accordingly.

In the industries using saggers for holding the ware during firing, a tunnel kiln will cause appreciable savings in sagger costs. This is because lighter loads are imposed upon the lower saggers of the bungs and because the handling of the saggers is much less severe than in periodic kilns. Also, the total number of saggers required to maintain a certain production will be less in a tunnel kiln because of the short firing period.

The tunnel kiln presents better working conditions for kiln labor, thus giving greater satisfaction to both employers and employed. In practically all cases, less actual physical labor is required per man per unit of ware handled. The drawing of kilns in which it is too hot for men to work safely and comfortably is eliminated.

Insurance rates are, in general, considerably lower for factories using tunnel kilns in place of periodic kilns. The insurance underwriter does not consider a periodic kiln in a building a very good risk. The lower premium in the case of the tunnel kiln is due to its construction and methods of insulation.

The use of the modern car tunnel kiln is a decided advantage to the clay industry at large, because successful tunnel kiln installations have started, probably as much or more than any other agency, the transformation of the old time clay plant, with its many sources of waste, into a modern efficient factory. The possibilities of the tunnel kiln have opened up the way for the way refinements throughout the clay industry.

The above list of advantages of the car tunnel kiln is only a compilation of those offered by different kiln designers. Special features of any particular car tunnel kiln are the means by which the designer effects the results claimed.

From an Investment Standpoint

One of the foremost thoughts, in the mind of a manufacturer considering the purchase of a tunnel kiln, is what will be the return on the investment? The answer to such a question will vary, depending upon several factors. These are the amount of the initial investment necessary, the savings possible, previous or comparative costs with which tunnel kiln costs will be compared, and whether the most will be made of the efficiency possibilities of the tunnel kiln.

The initial investment in a car tunnel kiln is greater in some cases than that which would be necessary to install a battery of periodic kilns to produce a similar amount of ware. Different types of clay bodies necessarily require different heat treatment, consequently capacity is controlled by the size of the kiln and the rate at which it can be operated to produce proper treatment. Therefore, the production desired will control to a very great degree the major portion of the initial cost.

It is essential for real successful operation, that a tunnel kiln be placed in a suitable building to protect the regulation of the kiln and to provide suitable working conditions for the men employed thereabouts. The cost of this building must be figured as part of the necessary investment. However, in practically all cases, the investment required to house a battery of periodic kilns of equivalent tunnel kiln capacity would be greater in order to obtain improved operating and factory conditions equal to that of the tunnel kiln.

The amount of savings possible with a tunnel kiln will vary with conditions. The factory and kiln layout will govern to a considerable degree the savings in labor costs. The unit cost of fuel, the firing temperature of the ware and the operating capacity of the kiln affect the amount of fuel saving in percentage and actual dollars and cents. The percentage of savings on former costs might be the same on different installations of the same design of tunnel kiln, which are operating on the same class and amount of ware, yet the actual amount of savings may not be alike, because of a change in one of the above factors. Other savings that may be obtained by using a tunnel kiln are dependent upon local conditions and the actual efficiency of the particular kiln under consideration.

If periodic kiln firing costs were high because of inefficient methods, then tunnel kiln operation would naturally produce larger savings than had the opposite been true.

Today, there are numerous successful tunnel kiln installations that a manufacturer can investigate so as to obtain reliable figures from which he can draw his own conclusions. There are several tunnel kilns now operating in which the fuel savings alone are returning to the owners each year 100% of the initial cost of the kiln.

A serious consideration of tunnel kilns by the clay products manufacturer at the present time is only good business foresight as the time is not far off when it will be necessary for practically all clay products factories to use tunnel kilns in order to lower production costs and meet competition. The tunnel kiln owner of today is realizing a larger margin of profit than his competitor who still uses the old style periodic kiln.

Preliminary Data for Investigating Different Designs of Tunnel Kilns

Before a manufacturer actually goes into the market for a tunnel kiln, there are several things to consider and decide, either in his own organization or in consultation with experienced engineers. Such points are factory layout, capacity, nature of the raw material and the characteristics of the particular ware to be fired.

Layout of Factory The tunnel kiln, because of its size, does not often readily fit into the average existing factory. Therefore, considerable study and forethought are required to make the kiln fit into the flow lines of production in the most efficient manner. In a new factory, the plant layout should be governed by the desired location of the kiln. Extra dollars spent in placing a tunnel kiln *in its logical location* will be returned many times when production gets under way. At all times in planning the layout, the idea of further expansion should govern the decisions made.

Production A car tunnel kiln is ordinarily operated every day of the week and production in the shop is main-

tained for only five and one-half or six days of the week. To meet this condition, the manufacturing department and the tunnel kiln must be synchronized in their operation so as to balance. Definite maximum production expected from the tunnel kiln should be decided upon, and plans made to operate the factory accordingly. A tunnel kiln is flexible within certain limits. That is, it may be operated under designed capacity with little loss in efficiency but if pushed much beyond capacity, the ware losses will probably increase and overcome any other advantages gained. Variation should be used only to take care of the unexpected. A tunnel kiln must be designed to meet the requirements of each particular installation. It is essential that maximum capacity requirements be decided upon at first so that the kiln designer may estimate the proper size of kiln needed.

If seasonal demand is an important factor in production planning, then a study of the relation of tunnel kiln capacity to average market and stock requirements will often reveal vital points. In some cases, it would be possible to reduce the amount of the initial investment required and to obtain lower manufacturing costs when operating. For example, a kiln designed for the maximum production of the busy season, would have to operate for only a short time after that period to produce enough ware for stock to last until the next season. This condition means idle equipment with accruing interest and depreciation, a part time labor force, and other manufacturing disadvantages. A smaller kiln operating the year around would meet average requirements and produce enough extra ware for the demands of the busy season. Each case has its advantages and disadvantages and the solution depends entirely upon individual conditions such as initial cost of kiln and factory layout, size of the factory, future expansion plans, interest on money invested in plant and stock carried and the local labor conditions.

The following information concerning the ware which it is planned to fire in a tunnel kiln, should be presented to the kiln designer for consideration. This includes sizes and weights of ware units, general composition and properties of the ware, present firing conditions with attendant problems, and any particular features of peculiarities of the body and ware. Such information together with production data and plant layout will allow a kiln designer to present accurate information concerning a proposed installation. Periodic kiln and tunnel kiln firing are really not comparable, still it is essential that periodic kiln practice be known.

Investigation of Market

A manufacturer intending to purchase a tunnel kiln should make a thorough study of the different designs of tunnel kilns firing his type of ware or a similar product. Though not essential, it is desirable that

samples of his ware be fired in tunnel kilns which have operating temperatures and conditions equal or near to those desired. A test of this type can only be made through the courtesy of another manufacturer who permits tests to be made in his kiln. Because of this and other reasons, it is usually impossible to test the quantity of material that most manufacturers would like to have tested.

In examining different types of tunnel kilns all particular advantages claimed by designers, general characteristics of the different kilns, and the attitude of the owners should be investigated. The high points of such an investigation will be discussed in the following paragraphs.

Determine the percentage of No. 1 ware being produced or, better still, determine the loss in fired product that can be charged to kiln operation. It must be realized that many kiln troubles can be corrected in the manufacturing departments and should be considered in the analysis of results obtained. For comparison, previous or comparative periodic kiln averages should be obtained.

How do the costs of maintaining a tunnel kiln compare with a similar cost of a battery of periodic kilns for equivalent production? Such costs must include those of repairing the kiln structure, replacement of car tops, upkeep of machinery (including cars), and repairs to fuel burning devices such as grates, stokers, or oil and gas burning equipment.

Practically all tunnel kiln users have means of obtaining exact fuel consumption for preparing accurate cost data. The cost of fuel consumed per unit of ware fired in the tunnel kiln should be compared with similar costs in periodic kiln firing taking into account the type of fuel and its costs. Fuel costs should include all charges incurred in delivering the fuel to the kiln and the removing of any waste. Power charges for operating kilns should also be included. Fuel consumption in the tunnel kiln will depend upon the following:

(*a*) Weight of ware fired per unit of time.
(*b*) Specific heat and composition of clay body fired.
(*c*) The finishing temperature of the product fired.
(*d*) The treatment required by the clay body.
(*e*) The efficiency of the different features of the particular kiln in use.

The capacity of a car tunnel kiln and the savings effected determine the return on the investment made in the installation. Tunnel kiln capacity should be figured in units of ware per day and not in cars. The investigator should learn the different capacities which the particular kiln has produced together with results. For comparison, the number of periodic kilns required to produce the capacity of the tunnel kiln should be determined. To do this the following formula may be used.

$$N = \frac{PT}{P_1}$$

In which

N = number of periodic kilns required.
P = daily production of tunnel kiln in units of ware.
P_1 = production of one periodic kiln per firing in units of ware.
T = Average turnover in days for one periodic kiln.

T should include time of setting, firing, cooling, drawing, cleaning, repairing and holidays during which the kiln is idle.

The amount of time taken to fire ware in the tunnel kiln should be compared with the length of the same operation in the periodic kiln. This time should be figured from the finish of setting to the start of drawing the ware. The difference in hours or days for these periods will determine the number of days gained in the turnover of raw material into finished product.

A close study of labor requirements and conditions should be made for comparison and future information. Actual labor includes tasks of setting and drawing of ware, moving kiln cars, cleaning up, actual firing of kiln and supervision. These items will vary, depending upon factory arrangement, car handling equipment, class of labor, amount and type of supervision, the policy of the management, and fuel used in the kiln. Also, the observer should note the amount of labor required to bring the ware to the kiln from drier or machine and to deliver the ware to the stock shed or delivery point.

Since every tunnel kiln installation is designed to produce certain results, only comparative costs of installation can be made of kiln and equipment needed, all of which control the initial cost of a tunnel kiln installation. So when investigating tunnel kilns, the type and size of building required, location of loading and drawing tracks, kiln control apparatus and mechanical handling equipment should be observed, so that all useful features can be considered or improved upon for the proposed installation.

Inquiry should be made as to what particular problems or trouble have been met in operating the particular tunnel kiln; also whether or not adjustment of the kiln itself was sufficient to overcome the trouble.

Problems in Tunnel Kiln Factory Operation

There are several problems that generally present themselves in factories installing tunnel kilns. These problems are not directly connected with the control of the tunnel kiln but concern the labor and management of the plant. A previous knowledge of these problems will hasten their solution when the time comes and thus increase the efficiency of the factory and the kiln.

It should be realized from the beginning, that a tunnel kiln is not a panacea for all the ills of a clay products factory. The tunnel kiln is

a device for producing and controlling a process which, because of its very nature, must be hidden to a relative extent from the operator. Time must be given for the development of the process in the kiln, therefore, the operator cannot expect that, by making a slight change in kiln controls, results will appear immediately. The tunnel kiln of today is as near perfect as present knowledge and experience can make it, yet with each particular kiln some unforeseen problems may arise and a longer period of adjustment than ordinarily necessary may be taken to overcome the trouble. A period of adjustment will always be necessary in starting a tunnel kiln and should be expected when installing a kiln. In other words patience is required.

In some clay products manufacturing plants, some of the organization will very likely think it almost sacrilegious to change any existing process that may have been used for years. Also the advent of a tunnel kiln into a clay plant, just like the entry of any revolutionary machine into an industry, will cause labor to look upon it with dubious eyes. The idea of continuous operation with necessary supervision often discourages those directly in charge of plant operations. Others, either through hearsay, lack of knowledge or experience, predict the failure of the kiln installation and so do not coöperate when the proper time comes. Such points are mentioned because they have been found to exist. It is essential that a manufacturer not only "sell" himself on the tunnel kiln idea but he must instill into his organization the enthusiasm necessary to make the installation a success from the start.

Skilled technical labor is not required to operate a tunnel kiln. A tunnel kiln operator needs only a common school education, a receptive and intelligent mind and habits of punctuality and attention to detail. If the kiln installation is equipped with means for moving the kiln cars along the return track, then one man should be able to place cars of green ware in the kiln, remove the finished ware cars from the kiln and watch the firing, unless coal is used. The men employed to set ware on the kiln cars should be impressed with the necessity of careful and uniform workmanship, because nine out of ten tunnel kiln wrecks can be attributed to carelessness or negligence on the part of the car setters.

There should be at least one man in the organization, preferably one with technical knowledge, who will understand all of the details of the kiln controls and operation and have direct supervision over the kiln and operators. Such a man will be able to make any adjustment of the kiln controls that might be needed at various times. Only a fraction of this man's time should be required to supervise the tunnel kiln and its operation.

The tunnel kiln affords excellent opportunities for a bonus wage system. It is a very simple matter to keep a complete check on each car of ware

and thus be able to place the blame for faulty workmanship. A tunnel kiln probably can be operated by cheap labor to some degree of success, yet common sense should restrain an owner from hiring a two-dollar-a-day laborer to take charge of a piece of apparatus in which is invested thousands of dollars, not only in the structure but in the ware in process through the kiln. Also, it is not good policy to give the fireman so much work that the control of firing is neglected.

It is generally found in tunnel kiln practice that the temperature range through which a particular clay body or glaze is matured, is shorter than in periodic kiln firing. Consequently, a very uniform temperature must be obtained throughout the setting of the ware in the tunnel kiln. Sometimes if trouble develops it is possible to fit a body or glaze to the tunnel kiln by making slight changes in composition and not lose any of the characteristic properties of the body fired. In general, though, a well-designed tunnel kiln has enough flexibility of controls to meet such conditions when they arise.

All the firing troubles of periodic kilns, such as "clay cracks," black-coring, bloating, dunting, soft and over-fired ware, blistering, flashing and "airing," can be encountered even when using a tunnel kiln. Some of these troubles occur when the capacity limits of the kiln have been exceeded, others because proper attention has not been given to the control of the kiln or where the kiln has not been adjusted to meet new conditions that have arisen.

The machinery used to operate the tunnel kiln is in constant service. Special attention should be given this equipment to keep it in good shape. The ordinary wear and tear on continuous-duty machinery should be realized and future replacements anticipated. An accessible stock of vital parts for the machinery equipment is good insurance for continuity of operation.

Conclusion

There have been a number of tunnel kilns built in this country, some failures, some mediocre successes, but the majority of recent installations are real successes. The manufacturer of today who thoroughly investigates the different types of tunnel kilns and then decides upon one whose success is assured by past performance and the reputation of its designers need have no fears as to the ultimate success of his choice.

Carl B. Harrop, Engineers and Constructors
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SCUMMING AND EFFLORESCENCE[1]

By M. E. Reynolds[2]

ABSTRACT

A. Drier Scum.

1. Soluble salts.
2. Iron sulphate and pyrite.
3. Sulphur in fuel and the addition of barium salts.
4. Lime bicarbonate.
5. Preheating versus scum.
6. Weathering versus scum.

B. Kiln Scum.

7. Sulphur in fuel.
8. Iron sulphide in clay.
9. Alkaline cooling scum.
10. Scum on sewer pipe.

C. Efflorescence on Fired Ware.

11. Soluble sulphates in soil.
12. Soluble salts in wall.
13. Rain water.
14. Mortar and adjoining material.
15. Yellow, green and brown spots.

The following is a brief summary of a portion of the literature which has been written on the subject of scumming and efflorescence in brick.

A. Drier Scum

1. The most numerous cases of scum occur in the drier or in the water-smoking period in the kiln and are caused for the most part either by the presence of soluble salts contained in the clay itself, the tempering water, or by the action of the sulphur gases from the fuel on the lime content in the clay. The most troublesome of the soluble salts are the sulphates of lime and magnesia or both together. Evaporation takes place from the surface of the brick, and as each minute portion of water is evaporated, its place is taken by another portion from the interior of the brick. Each small portion of water carries its load of soluble salt and deposits it on the surface of the brick causing a scum, which being about the same color as the dried brick, does not show up until the darker fired color of the ware makes it visible.

2. Many clays contain sulphide of iron (pyrite), which is changed to iron sulphate by the action of air and moisture. This causes a brown scum which would not be objectionable in red firing ware, but the iron sulphate, when it comes into contact with fine limestone, a constituent of some clays, forms lime sulphate which is deposited as a white scum. Most tempering water contains lime sulphate and in this case the sulphur may be present in the water and the lime in the clay. The reaction of the two would deposit lime sulphate on the brick as a scum.

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[1] Presented to the Pacific Northwest Claymakers' Association, Jan. 17, 1925.

[2] Department of Ceramic Engineering, University of Washington.

3. The burning of coal or other sulphur-containing fuel to heat the drier will cause the evolution of sulphur gases, which unite with the moisture in the drier to form sulphuric acid. If these products of combustion should get into the drier, the resulting acid will attack the lime carbonate in the clay, causing a scum of lime sulphate to be deposited on the ware. In cases where the heat is supplied by waste gases from the kiln the same sulphur gases will be introduced, causing the same scum. Where the heat is supplied by gases from the cooling kiln, the sulphur content in most cases will be negligible.

Where soluble sulphates are the cause of scumming, the addition of barium compounds will in most cases be a remedy. Barium carbonate will, in many instances, do the work, changing the lime sulphate into insoluble barium sulphate and leaving insoluble calcium carbonate.

TABLE I

SOLUBILITIES OF DIFFERENT SALTS

One part salt	Parts of water required for solution	One part salt	Parts of water required for solution
Calcium sulphate	495.00	Magnesium chloride	0.60
Calcium carbonate	77,000.00	Barium sulphate	435,000.00
Calcium hydroxide	590.00	Barium carbonate	45,450.00
Calcium chloride	1.37	Barium chloride	3.00
Magnesium sulphate	3.75	Barium hydrate	27.00
Magnesium carbonate	9,400.00	Iron sulphate	3.00

Barium carbonate, being only slightly soluble, will in some cases have insufficient time to react with all the sulphates, in which case, according to Professor Binns, a more soluble form of barium should be used. He says that barium chloride which costs from $72.00 to $76.00 a barrel on the New York market, would be the cheapest because it is soluble in water and therefore distributes itself more thoroughly through the clay, but that it is dangerous, for if a slight excess is used it will cause a scum itself.

A simple method to determine the amount of barium salts necessary to stop the action of the soluble salts in clay is described by Prof. Parmelee as follows: Into each of several small glass jars an equal weight of clay is placed and equal amounts of distilled water added to each sample. The samples are then stirred well. Into one jar is placed a measured quantity of dilute barium chloride solution of known strength, which has been prepared with distilled water. Into a second jar a slightly larger quantity is placed and so on for the remainder of the jars, increasing the quantity in each succeeding jar. The samples are now agitated and allowed to settle. After standing for several hours a small amount of the clear liquid is poured off and if turbid is clarified by filtering or adding a trace of muriatic acid. When clear, a drop of sulphuric acid is added to each sample. If a white cloud forms it is evident that too much barium chloride has been

added. If the fourth sample remains clear upon the addition of sulphuric acid and the fifth sample shows a little white cloudiness, it is plain that the sixth sample contains just a trifle of barium chloride in excess. Knowing the weight of the clay used and the strength of the chloride, it is easy to calculate the exact amount of barium chloride or carbonate which will be sufficient to precipitate all of the soluble sulphates. To find the proper amount of barium carbonate multiply the weight of chloride by 0.80. The carbonate is far less soluble and reacts more slowly so that an excess should be used for quick work. An excess of carbonate will not cause scum, but an excess of chloride will give a chloride scum. Seger advises the use of double the amount calculated. The Germans advise the use of a slightly insufficient amount of barium chloride with an excess of barium carbonate, saying that no trouble will be experienced from this source as the barium carbonate is but slightly soluble and an excess can do no harm. Prof. Binns states further that the action of the barium has nothing to do directly with the lime; all it does is to take possession of any sulphur that may be present so that there is nothing for the lime to combine with to form a soluble salt. The use of barium is also a remedy when the scum is caused by the sulphur from the coal or waste kiln gases, as it sets a trap for the sulphur and no calcium sulphate can be formed. Barium hydroxide has also been used.

4. In the same article, Prof. Binn states, "If carbonic acid is present in the tempering water the lime may be in the form of a bicarbonate, a soluble form of calcium, or in the form known to druggists as lime water. These forms do not in themselves cause troublesome scums, but if the clay contains a large amount of lime a bad scum may appear. The only remedy here is to change the water supply or to doctor the water. The addition of quicklime will precipitate the bicarbonate, but care must be used and the proper amount of quicklime necessary determined by experiment. If an excess is used new lime water may be formed.

5. In the case of highly colloidal sticky clays, soluble salts may be absorbed by the clay. When these clays are preheated to reduce shrinkage, the plasticity is reduced and the clay will release some of the soluble salts which will come out in the drier and cause scum.

6. Weathering clay will in some cases tend to reduce scum and in other cases to increase it. Highly soluble salts such as ferrous sulphate will be washed out of the clay in the process of weathering by rain water. On the other hand, if clays which are high in iron pyrite are weathered the pyrite will be changed by the action of air and moisture into iron sulphate which will come out later as drier scum.

Slow drying facilitates the formation of scum, while rapid drying tends to prevent it by holding the sulphate inside of the product. Open porous structures are less liable to show drier scum than dense ones, as the soluble

salts are deposited in the body of the ware or on the walls of the pores. Rough texture brick are less affected by scum than smooth ones for the surface of the brick has a larger area on which the scum is deposited, and the effect is diluted. In rough brick variation is wanted, and slight scum would not be detrimental, for in some cases it might give exactly the desired effect.

B. Kiln Scum

7. All coal contains sulphur and, when burned, sulphur gases are evolved, which uniting with the moisture remaining in the brick forms sulphuric acid. This acid attacks the carbonate and other calcium salts to form sulphates which are deposited on the ware as scum, the same as drier scum. This scum is stable except under reducing conditions, therefore the atmosphere of the kiln should be kept in as good a reducing condition as the structure and fired color of the ware will permit.

8. The iron sulphide (pyrite) in the clay is decomposed at 750°C while the sulphuric acid is volatilized at 680°C. During the early part of the firing the temperature in the upper part of a down-draft kiln may be high enough to decompose the pyrite and liberate sulphur, while the lower part of the kiln is at a temperature below that of the volatilization of sulphuric acid. The liberated sulphur will unite with the moisture, forming sulphuric acid. The action of the acid is to decompose the carbonates of lime and the feldspars forming the sulphates, which are deposited as scum on the brick in the lower part of the kiln. The best remedy for both of the preceding cases would be to heat the kiln to 680°C with wood or some non-sulphur containing fuel. This heating should be done under oxidizing conditions as the sulphur in the pyrite is not released as easily under oxidizing, as under reducing conditions. By driving off the moisture in this way and then using clean dry fuel, no sulphuric acid can be formed and scum from this cause will be eliminated.

Wet brick set in the kiln are more apt to scum than dried brick as the evaporation of water in the brick retards their heating and affords a good place for the condensation of the sulphuric acid. The acid diffuses through the brick forming sulphates which are carried to the surface and deposited.

9. A whitish coating is sometimes found upon brick after opening the kiln, especially upon those near the door, or appearing soon after removal from the kiln. This scum, which analysis shows to be composed chiefly of sodium sulphate with sodium chloride, a little calcium sulphate and no magnesium sulphate, is readily removed by washing. The probability is that the scum was formed during the cooling of the kiln, otherwise the sodium chloride, at least, would have been volatilized. The source of the sodium is probably from the ashes and clinker in the cooling fireboxes and the sulphur for the sulphate from the same source. To pre-

vent the occurrence of this scum the fire-boxes should be cleaned when the firing has been completed and before the cooling starts.

In some cases a brown scum may be produced with iron salts which will give a polychrome effect of irregular lines on buff and red fired ware. There is a field for future work in developing polychrome color schemes by artificial addition of iron salts.

10. A white scum is often found on sewer pipe a short time after they are removed from the kiln, and is due to excess salt fumes in the kiln atmosphere, which had not been drawn off at the stack, but were redeposited on the ware. The first heavy rain will wash it off; or a light fire may be used to burn it off after the salting has been completed.

C. Efflorescence on Fired Ware

The staining or scumming of brick after they are removed from the kiln to the yard, and after they are set in the wall is generally spoken of as efflorescence. It is very troublesome and is caused in several different ways. The remedies have not been very thoroughly studied.

11. Many brickyards use the ashes and clinkers for filling in around the yard, and the soil becomes saturated from the soluble salts being washed from the clinker. If brick are piled on this ground, they will absorb the salts from the soil. Later these will be leached out and appear as efflorescence, chiefly at the bottom of the pile. The ground should be paved with hard brick or plank laid under the pile.

12. Efflorescence may be caused by the gradual leaching out of some soluble sulphates left from the firing and also from the breaking down of silicates and a combination of the bases with sulphuric acid from the atmosphere, or from the remaining pyrite in the ware. The most common constituent of this efflorescence is the sulphate of calcium which is not dissociated until the temperature in the kiln reaches 1200°C (2192°F). In some cases it may be formed by magnesium and alkali sulphates if the brick are low fired. If the ware is hard fired all these sulphates are decomposed and taken up into silicate formations and therefore become harmless.

13. Efflorescence is often produced after a heavy storm by the rain water, which enters the brick and mortar and upon evaporating carries to the surface some of the soluble salts. This coating is usually washed away by the next rain, although sometimes it may remain collected in blotches. A solution of muriatic acid will remove the blotches and if it occurs frequently the brick may be coated with paraffine or linseed oil. This will make them darker, but will also make them impervious to the rain water.

14. Many cases of efflorescence are not due to any fault of the brick but can be laid to the mortar, which may contain soluble salts of mag-

nesium, calcium, sodium and potassium. Rain soaking into the jointing material carries the soluble salts over the faces of the brick thus discoloring them. Also when lime mortar is used, calcium hydroxide is formed. This compound is almost as soluble as the sulphate, which is one of the main causes of drier scum. When laid in wet weather the wall will be soaked with water which will carry the salt to the surface where it evaporates. It will then combine with the carbon dioxide in the air to form calcium or lime carbonate. This will wash off readily in the next rain but may reappear due to the slowness of the reaction in the interior of the wall.

The use of sandstone decoration on brick buildings is the cause of much discoloring of the brick, for the sandstone is, in many cases, impregnated with soluble salts, which are leached out and run down on the brick, discoloring them, and in some cases being leached through the brick. The use of a thin sheet of copper under all stone courses, with the edge projecting and turned down to form a drip, would eliminate this scum.

15. Efflorescence in the form of yellow, green and brown spots may be due to several agencies. Occasionally it is caused by the growth of some low vegetable organism which takes its nourishment from the brick and the air. In one case investigated by Seger, the spots were found to be due to chromium compounds. In a good many cases the spots were caused by vanadium, in the form of vanadic acid, and occurs mostly on the underfired brick. This may be remedied by firing the kiln to a higher temperature, and in such a way that the kiln is periodically filled with a reducing atmosphere. The chemistry of the reaction is that the soluble vanadic compounds are reduced to insoluble vanadous oxide and fixed by fusion at the higher temperature with the silicates. The spots might also be caused by the presence of some soluble iron salts which were not fused in the firing. The chemistry of iron salts and colors has not been thoroughly investigated but it is suspected that some terra cotta cleaned with muriatic acid will develop yellow spots of iron chloride.

Experimental work should be done in local sands, mortar, lime and Portland cement to determine their content of soluble salts.

Bibliography of Scumming and Efflorescence[1]

1. C. W. Parmelee, "Soluble Salts in Clay Wares," *Brick and Clay Record*, August 22, 1922, p. 249; and p. 316, Sept. 5, 1922.

2. Charles F. Binns, "Efflorescence and How to Stop It," *Brick and Clay Record*, p. 1017, Nov. 18, 1913.

3. Arthur E. Williams, "How to Prevent Efflorescence in Finished Brickwork," *Brick and Clay Record*, p. 341, Sept. 7, 1915.

[1] See also F. G. Jackson, "A Descriptive Bibliography of Scumming and Efflorescence," *Bull. Amer. Ceram. Soc.*, **4** [8], 376–401 (1925).

4. "Scumming, Efflorescence and Whitewash," *Brick and Clay Record*, p. 602, April 18, 1922.

5. "Collected Writings of Hermann A. Seger," p. 396. "On Barium Compounds as an Addition to Clay in the Manufacture of Face Brick."

6. "Collected Writings of Hermann A. Seger," p. 381. "Yellow and Green Efflorescence on Brick Fronts."

7. "Collected Writings of Hermann A. Seger," p. 369. "The Influence of the Sulphur in Coal upon Clay Wares."

8. "Collected Writings of Hermann A. Seger," p. 376. "A Contribution to the Knowledge of Efflorescence on Terra Cotta."

9. J. C. Jones, "Efflorescence of Brick," *Trans. Amer. Ceram. Soc.*, **8**, 369(1906).

10. Ellis Lovejoy, "Scumming and Efflorescence," The Lovejoy Eng. Co., Columbus, Ohio.

11. F. G. Jackson, "The Behavior of Calcium Compounds in Clay," *Jour. Amer. Ceram. Soc.*, **7**, 427(1924).

12. C. W. Parmelee, "Soluble Salts and Clay Wares," *Jour. Amer. Ceram. Soc.*, **5** [8], 538(1922).

13. M. E. Gates, "A Satisfactory Method of Using Barium Hydrate in Terra Cotta Bodies," *Jour. Amer. Ceram. Soc.*, **3**, 313(1920).

WHAT IS THE EFFECT OF TANK CONDITIONS ON SELENIUM COLOR?[1]

By R. R. Shively

It is impossible to determine the amount of selenium actually necessary for decolorization. The average amount used in the batch is less than one part in 80,000 parts of finished glass and, as some of this is lost by volatilization or oxidation, it is quite impossible to find by analysis the amount of selenium remaining in the finished glass.

A few manufacturers do not use arsenic and the amount of selenium required for their batch is unusually small. I know of one factory where raw materials of low iron content are used that required but 0.125 ounce of selenium combined as a selenite to decolorize a thousand pounds of sand. Another factory not using arsenic requires but 0.25 ounce of selenium for one thousand pounds of sand. Where the average amount of arsenic is used (two pounds to the thousand of sand) the amount of selenium required to the batch is about 0.5 of an ounce. Where a selenite is used even a smaller quantity is required. It can be seen from the above facts that very little selenium is required for decolorization and if any unusual amount of it is lost through furnace conditions it would seriously affect the color.

Selenium melts at 217°C. It burns in the air with a bluish red flame forming selenium dioxide, and boils at 690°C. From these properties it would be expected that some of the selenium introduced in the furnace is

[1] Presented at the Annual Meeting, American Ceramic Society, Feb., 1925. (Glass Division.)

lost by volatilization and, in the case of a tank operating under oxidizing conditions, some of the selenium may combine with oxygen and the selenium dioxide carried out with the stack gases.

Let us consider for the time ruby glass where a much larger amount of selenium is used. Ruby batches made in pots require much less selenium than those made in tanks. In the latter case I am informed that everything depends upon the flame. A certain batch may give a good glass one day and the next melt may be unfit for use. The fumes of selenium can be seen escaping from the tanks. If where larger amounts of selenium are used the operation of the furnace is so important it certainly has its influence in a lesser degree where small quantities are employed.

It has been my experience that the hotter the tank is run the less selenium is required for decolorization. This may be explained by the fact that where high temperatures are obtained, the furnace is being operated efficiently and a neutral condition is maintained within the furnace.

Unquestionably tank conditions affect to some extent selenium decolorization. Constant temperatures and uniform furnace conditions must be maintained in order to get the best results.

M. F. CURTIS: Do you know whether selenium is introduced in any other form besides metal and selenite?

R. R. SHIVELY: No, the only form of selenium being sold here is the amorphous, known as metallic and sodium selenite. There is a very small amount of red selenium coming into this market. It is very finely powdered and I am informed that it is not satisfactory. It is a little cheaper but it requires so much more to get results.

M. F. CURTIS: Do you know any reason why it is not possible to use selenite of soda?

R. R. SHIVELY: There is no sodium selenite used. The selenites are a little harder to prepare. It is rather expensive.

A. R. PAYNE: Some have said that in the leers the pinkness of a selenium decolorized article is higher in the back end of the leer than at the front of the leer.

Our experience has been absolutely contrary to this. We always have a slight fading or a burning out of the high color after leaving the machines. Of two tumblers made consecutively we can always tell which one has been through the leer and which one has not. The one that has not been through the leer is of high color while the one that has been through the leer is just right. We have to regulate it according to what is at the back end of the leer.

R. R. SHIVELY: May I ask if you use any manganese color in your glass?

A. R. PAYNE: No.

R. R. SHIVELY: I have seen the condition you speak of occurring where they use manganese coloring along with the selenium but you are the

only place of all the factories I have visited that has not at some time run into red glass in leers. The glass will be perfectly good color when it goes in the leers. The leer adjacent may be a little hotter. The glass ware on that side will turn perfectly pink. I have seen the glass on either side of the leer pink and that in the middle a little low in color.

There is one particularly odd thing I saw. An open leer was leaking a little bit at the muffle, a little flame was shooting out. It was an old hand-operated leer. They would pull this leer one pan at a time and about every two feet a half dozen jars would be absolutely pink where the flame was. This was the first time I noticed this and I thought they were gathering red and green glass out of the same hole.

A. SILVERMAN: Dr. Shively, have you run across any samples of selenium adulterated with tellurium and have you noticed any perceptible effects in glass?

R. R. SHIVELY: We analyze every shipment of selenium we get and in practically all cases we find a small amount of tellurium present but rarely over 0.2% or 0.3%. I might say in this connection that selenium analyzes approximately 99% selenium and I have never found tellurium added as an adulterant.

M. F. CURTIS: Do you know of anyone treating metallic selenium with concentrated sulphuric acid before it is added to the batch to get a ruby glass?

R. R. SHIVELY: I have never heard of that. There are certain manufacturers of ruby glass who use a selenite but most of them use the metallic selenium.

M. F. CURTIS: You get a selenite by treating with concentrated sulphuric acid. I know one place where that is being done. I was not able to determine the reason.

H. L. DIXON: While this discussion is on I wonder if anybody can tell why manganese was used from time immemorial as a decolorizer and it took a world war to get them out of that rut and start them on selenium.

You know one of the hardest things in making flint glass in a tank with manganese was the absence of color. The manganese is so susceptible to atmospheric conditions in the furnace. Now that has all been passed up and they use selenium almost universally and I have often wondered since selenium was available before why somebody had not used it.

R. R. SHIVELY: The first selenium that came to this country was brought over by Mr. Nicholkopf who made ruby glass in 1894. That selenium cost $28 a pound. Until a few years ago selenium was rather hard to get. It was expensive. Today there is being marketed in this country approximately 15,000 pounds of selenium a month, and I am told in the refineries that they are refining lower grades all the time in order to

get the output. The company that I represent has had in the early days of selenium as much as 50,000 pounds of selenium in storage at one time and at the price it was at that time it represented quite a little money. That was before selenium became so generally used.

Today our shipments are right up to production. We have trouble at times to keep production going. It was not used more because it was very expensive. A good deal of work had been done in Germany with it as a decolorizer, but it was not taken here seriously until we were forced to it. The old saying, "Necessity is the mother of invention," applies here.

A. R. PAYNE: This is a case where a man patented something 25 years too soon. I think the German patent on this use of selenium came out about 1894.

ACTIVITIES OF THE SOCIETY

R. C. PURDY TO REMAIN IN OFFICE OF GENERAL SECRETARY OF THE AMERICAN CERAMIC SOCIETY

It is with pleasure that the Board of Trustees announces that Ross C. Purdy, on request by the Board and several members, has reconsidered and withdrawn his resignation as Secretary of this SOCIETY as reported in the June *Journal*. This decision will be welcomed by all members of the SOCIETY.

Mr. Purdy's success as Secretary of the SOCIETY and as Editor of the *Journal* is recognized within and without the SOCIETY and his demonstrated ability in these offices, together with his real interest in the affairs of the SOCIETY makes a rare combination for which the SOCIETY may well be thankful. Let us all in word and action give united support to Secretary Purdy in his editorial and secretarial work.

E. WARD TILLOTSON, *President*

AMERICAN CERAMIC SOCIETY ANNUAL MEETING

Atlanta, Ga., February 8-13 Inclusive

(Headquarters—Hotel Biltmore)

Seven meetings in one—Art, Enamel, Glass, Heavy Clay Products, Refractories, Terra Cotta and White Ware.

Technical sessions through to Thursday noon and then a trip through Wilkinson County from Macon, Gordon, McIntyre and Stevens Pottery, starting Thursday noon and continuing through Saturday.

A "cut-up" evening on Tuesday with the Woman's Club of Atlanta as hostess, a banquet Wednesday evening with sparkling southern wit and entertainment, an auto-lunch box picnic trip to Stone Mountain Thursday noon, a special train to Macon and a complimentary dinner, a barbecue Friday noon at Gordon and a lunch and golf in Macon Saturday afternoon are the social affairs.

Clay mines and clay plants will be visited.

A big exhibit will be shown in the store and sample rooms of Hotel Biltmore.

One and one-half fare on certificate plan has been granted by the several passenger associations. Here are the fares one way from several points. Note that the numbers on the map and in the following table correspond. This will show that it will cost no more to get to Atlanta than to other meeting places.

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1. Chicago
Fare $26.72
Lower Berth $8.25

Chicago and Eastern Illinois trains leaving Chicago 11.55 A.M., 12.25 P.M. and 9.45 P.M.; Pennsylvania R. R. train 9.15 P.M. and Big Four trains at 10.10 A.M., 1.00 P.M., 9.15 P.M. and 11.40 P.M. carry through sleepers with dining service to Atlanta.

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2. Detroit
Fare $26.68
Lower Berth $8.25

Michigan Central train, "The Flamingo," leaving Detroit at 12.20 P.M. is a through train to Atlanta. Through sleepers and dining service on train leaving at 12.50 P.M.

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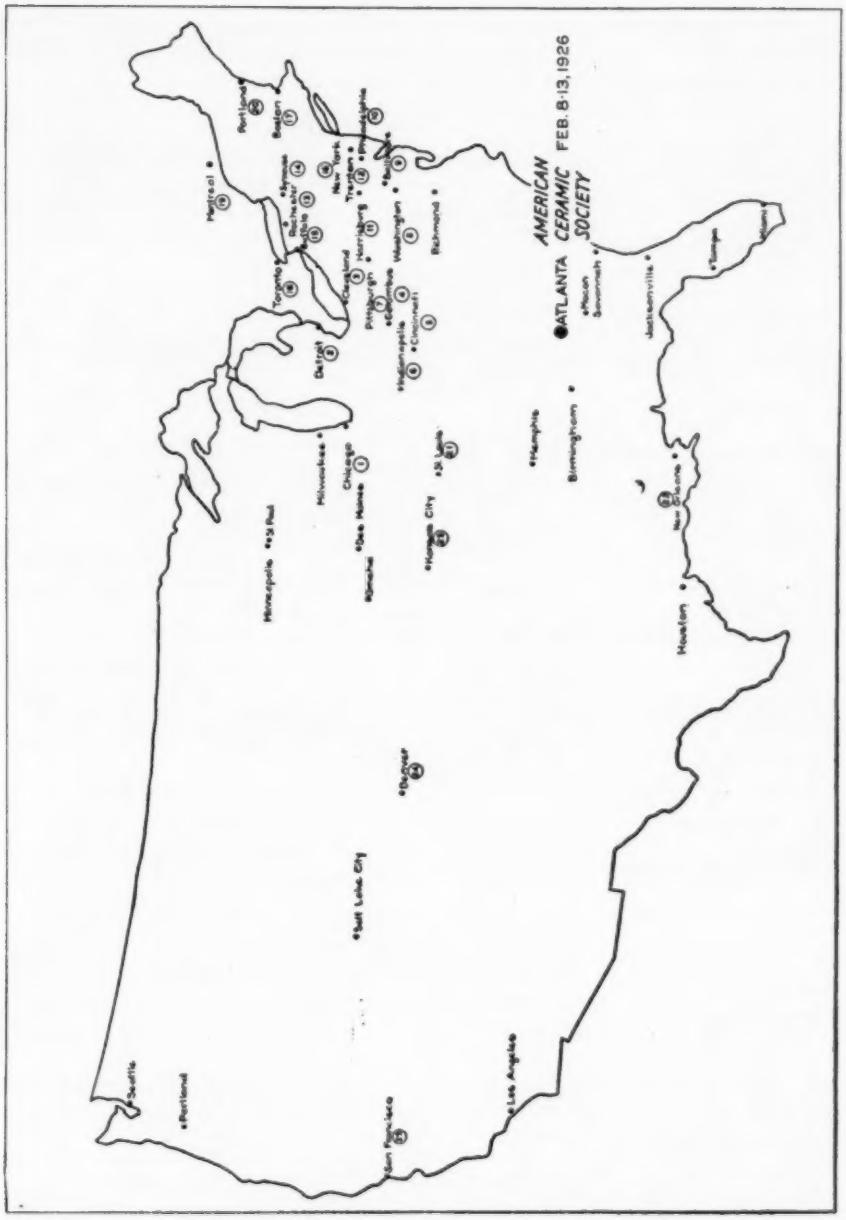
3. Cleveland, Ohio
Fare $26.45
Lower Berth $8.25

Through sleepers and dining service Cleveland to Atlanta on Big Four trains leaving Cleveland 12.00 noon and 3.45 P.M.

4. Columbus, Ohio **Fare $21.61** **Lower Berth $5.63**	Big Four trains leaving Columbus 3.15 P.M., "The Flamingo," and 7.05 P.M., "Suwanee River Special," go through to Atlanta. Or, use any train to Cincinnati and through trains from there. See No. 5.
5. Cincinnati **Fare $17.30** **Lower Berth $4.50**	Louisville and Nashville trains leaving Cincinnati 6.27 A.M., 7.00 P.M. and 8.00 P.M., and Southern Railway trains leaving at 8.50 A.M., 6.45 P.M. and 9.50 P.M. are through trains with dining service to Atlanta.
6. Indianapolis **Fare $20.47** **Lower Berth $5.63**	Pennsylvania R. R. leaving Indianapolis 10.00 P.M. and Big Four leaving at 6.15 P.M. carry through sleepers with dining service to Atlanta. Or, use any train to Cincinnati and through service from there. See No. 5.
7. Pittsburgh **Fare $28.49** **Lower Berth $8.63**	Use any convenient train to Cincinnati and through trains from there. See Nos. 4 and 5.
8. Washington, D. C. **Fare $27.91** **Lower Berth $7.50**	R. F. and P. trains leaving Washington 8.50 A.M. and 6.35 P.M. and Southern Railway trains at 12.20 A.M. (sleeper open 10.00 P.M.), 11.00 A.M., 3.45 P.M., 9.35 P.M. and 10.50 P.M. carry through sleepers and dining service to Atlanta.
9. Baltimore **Fare $29.35** **Lower Berth $7.50**	Trains leaving Baltimore over Pennsylvania R. R. at 6.03 A.M., 2.20 P.M., 8.06 P.M. and 11.05 P.M. have through sleepers and dining service to Atlanta.
10. Philadelphia **Fare $32.81** **Lower Berth $8.63**	Pennsylvania R. R. trains leaving Philadelphia 12.13 P.M., 5.48 P.M. and 8.47 P.M. have through sleepers and dining service to Atlanta.
11. Harrisburg **Fare $30.34** **Lower Berth $10.13**	Take Pennsylvania R. R. to Baltimore or Washington and through trains from those points. See Nos. 8 and 9.
12. Trenton **Fare $29.07** **Lower Berth $9.75**	Pennsylvania R. R. trains leaving Trenton 11.26 A.M., 4.58 P.M. and 8.00 P.M. carry through sleepers and dining service to Atlanta.
13. Rochester **Fare $44.46** **Lower Berth $12.00** **Fare $35.49** **Lower Berth $12.00**	Use New York Central or Lehigh Valley to New York City and through trains from there to Atlanta. See No. 16 or Use New York Central and Big Four via Cincinnati. See 3, 4 and 5.


AMERICAN CERAMIC SOCIETY
FEB. 8-13, 1926
ATLANTA
Portland
Boston
Portland
Seattle
Portland
San Francisco
Los Angeles
Salt Lake City
Denver
Minneapolis
St. Paul
Milwaukee
Chicago
Des Moines
Kansas City
St. Louis
Memphis
Birmingham
Houston
New Orleans
Jacksonville
Detroit
Cleveland
Pittsburgh
Indianapolis
Cincinnati
Washington
Richmond
Toronto
Buffalo
Rochester
Syracuse
New York
Trenton
Harrisburg

14. Syracuse
Fare $38.38
Lower Berth $12.00
Fare $41.56
Lower Berth $12.00

Use New York Central and Big Four via Cincinnati. See 3, 4 and 5 or

Use through service on Lackawanna or New York Central to New York and Philadelphia and through trains to Atlanta from those points. See 10 and 16.

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15. Buffalo
Fare $35.86
Pullman 12.00
Fare $33.01
Lower Berth $12.00

Through service to Atlanta through Philadelphia or Washington on Pennsylvania. See 8 and 10 or

Through service over New York Central via Cincinnati. See 5.

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16. New York City
Fare $31.11
Lower Berth $9.75

Pennsylvania R. R. leaving New York 12.45 A.M. (sleeper open 10.00 P.M.), 10.10 A.M., 3.40 P.M. and 6.40 P.M. Through sleepers and dining service to Atlanta.

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17. Boston
Fare $40.27
Lower Berth $12.38

New York, New Haven and Hartford through trains to New York and Washington and through trains from those points to Atlanta. See Nos. 8 and 16. Train leaving Boston 9.00 A.M. carries through sleeper to Atlanta.

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18. Toronto
Fare $36.68
Lower Berth $12.00

Canadian National and Canadian Pacific operate through service to Cleveland or Detroit. Through trains from those points to Atlanta. See Nos. 2, 3 and 5.

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19. Montreal
Fare $46.02
Lower Berth $15.00

Use Canadian National or Canadian Pacific through trains to New York or Washington. Through trains from those points to Atlanta. See Nos. 8 and 16.

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20. Portland, Me.
Fare $44.19
Lower Berth $15.00

Take parlor or sleeping car over Boston and Maine to Boston or New York and through service to Atlanta from those points. See Nos. 16 and 17.

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21. St. Louis
Fare $22.53
Lower Berth $6.75

Louisville and Nashville trains leaving St. Louis at 8.44 A.M., 2.00 P.M., 3.36 P.M., 9.25 P.M. and 11.30 P.M. (sleeper open 9.00 P.M.) carry through sleepers with dining service to Atlanta.

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22. New Orleans
Fare $17.78
Lower Berth $5.63

Louisville and Nashville trains leaving New Orleans 8.30 A.M., 5.00 P.M. and 10.00 P.M. carry through sleepers with dining service to Atlanta.

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23. Kansas City
Fare $32.57
Lower Berth $9.00

Frisco Line trains leaving Kansas City 9.00 A.M. and 6.00 P.M. carry through sleepers with dining service to Atlanta. Or, use any train to St. Louis and through trains from there. See No. 21.

24. Denver
Fare $55.25
Lower Berth $15.38

Rock Island train leaving Denver 9.15 P.M. carries through sleeper with dining service to Atlanta. Or, use any train to Kansas City or St. Louis and through service from those points. See Nos. 21 and 23.

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25. San Francisco
Fare $82.83
Lower Berth $26.25

Use any train to Chicago, St. Louis, Kansas City or New Orleans and through service from those points. See Nos. 1, 21, 22 and 23. Southern Pacific trains leaving San Francisco 4.50 P.M. carry through tourist sleeper to Atlanta. Tourists sleeping car rate $13.13.

NEW MEMBERS RECEIVED FROM OCTOBER 15 TO NOVEMBER 15

PERSONAL

J. Newton Barnes, P. O. Box 355, Macon, Ga., Secy.-Treas., J. S. Schofield's Sons Co.
Marion Luther Brittain, President, Georgia School of Technology, Atlanta, Ga.
Joseph F. Butler, Box 135, Hoboken, N. J.
Henry Graham Carmichael, 2117 Reading Rd., Cincinnati, Ohio, Pres., Cincinnati Tile and Pottery Co.
Lorenzo S. Cope, 2440 E. 75th, Cleveland, Ohio, Mechanical Engineer, The National Screw & Manufacturing Co.
Harvey Willard Culp, Lab. Asst., Babcock and Wilcox Co. Lab., East Liverpool, Ohio.
Robert Earl Evans, Vice-Pres., Georgia White Brick Co., Gordon, Ga.
Frederick P. Golding, Manager, Golding Sons Co., Butler, Ga.
Jack U. Gould, 710 E. 14th St., New York City, Asst. in charge of Lab., Eagle Pencil Co.
George Guthrie, 61 Mungalhead Rd., Falkirk, Scotland, Technical Chemist.
Orris F. Houk, Gen. Mgr., The Central Refractories Co., New Lexington, Ohio.
Clayton S. Houpt, 5661 Natural Bridge Ave., St. Louis, Mo., Supt., Enamel Dept., Wrought Iron Range Co.
Leander R. Kirk, Cambridge Sanitary Mfg. Co., Cambridge, Ohio.
William C. Koch, Treas. and Gen. Mgr., Twin City Brick Co., 514–19 Pioneer Bldg., St. Paul, Minn.
Chi-fang Lai, Box 233, Station A, Ames, Iowa, Graduate Student.
Stewart J. Lloyd, Prof. of Chemistry, Univ. of Ala., Consulting Chemical Engineer and Geologist, Tuscaloosa, Ala.
Arthur B. Long, Westfield Clay Products Co., Westfield, Mass.
Thomas B. McCoun, Box 578, Lexington, Ky., President and Gen. Mgr., Bybee Pottery Co., Inc.
E. L. Miller, Manager, Nivison Weiskopf Co., Reading, Ohio.
Howard M. Parkhurst, 2728 Boone St., Ames, Iowa, Student.
Edwin B. Streater, 2120 Lincoln Way, Ames, Iowa, Student.
David Thomason, % Edwards and Ames, 619 Pacific Bldg., Vancouver, B. C.
Clifton W. Walters, Supt., Farber Fire Brick Co., Farber, Mo.
David McKay Webster, Chemist and Asst. Mgr., Enameling Dept., Gowanbank Iron Works, Falkirk, Scotland.
Frank C. Westendick, 52 W. Blake Ave., Columbus, Ohio.
Robert A. Whitfield, The Hegeler Zinc Co., Danville, Ill., Chemist.

CORPORATIONS

Farber Fire Brick Co., A. S. Zopfi, Secy.-Treas., Farber, Mo.

Kreischer Brick Mfg. Co., Face Brick Mfrs., Box 135, Hoboken, N. J. J. F. Butler, Representative.

Queen's Run Refractories Co., Inc., Lock Haven, Pa. Geo. H. Diack, Gen. Mgr.

Membership Workers' Record

	Personal		Personal	Corporation
F. E. Allen	1	F. H. Norton	1	
P. E. Cox	1	R. H. Pass	1	
W. B. Cleverly	1	A. Silverman	1	
E. A. Eigenbrot	1	N. Stein	1	
H. W. Harrington	1	A. S. Zopfi	1	1
A. V. Henry	1	C. B. Young	1	
W. K. McAfee	1	Office	9	2
J. M. Mallory	2		—	—
J. M. Manor	1		26	3
D. A. Moulton	1			—
			TOTAL	29

MEMBERSHIP RECORD FOR 1925

	PERSONAL		CORPORATION	
	1924	1925	1924	1925
January	31	24	6	1
February	40	19	8	2
March	29	35	..	6
April	35	9	3	1
May	25	15	4	3
June	18	15	2	2
July	14	15	3	..
August	9	12	..	1
September	9	9	..	2
October	17	14	2	1
November	11	26	2	3
TOTAL	238	193	30	22
December	11		..	
TOTAL	249		30	

We are listing the names of the membership workers for 1925 (up to November 15). Whether you see their names on membership committees or not they are functioning actively in membership solicitation for the AMERICAN CERAMIC SOCIETY. C. F. Geiger of Carborundum Company, Perth Amboy, N. J., has membership honors with five personals and two corporations. Dr. Silverman of the University of Pittsburgh runs a close second with five personals and one corporation. W. L. Shearer and R. A. Weaver are tied for third place with five personal memberships each.

F. E. Allen, 1 P.
C. E. Bales, 2 P.
L. E. Barringer, 2 P.
M. F. Beecher, 1 P.
A. V. Bleininger, 1 P.
C. F. Binns, 1 P.
G. A. Bole, 1 P.
M. W. Butler, 1 P.
W. B. Cleverly, 1 P.
P. E. Cox, 2 P.
H. E. Davis, 1 P.
Dover Fire Brick Co., 1 P.
E. A. Eigenbrot, 3 P.
K. H. Endell, 1 P.
R. F. Ferguson, 2 P.
G. A. Forbes, 1 P.
D. H. Fuller, 1 P.
C. F. Geiger, 5 P., 2 C.
R. F. Geller, 1 P.
R. E. Gould, 1 P.
M. C. Gregory, 1 P.
J. E. Hansen, 1 P.
H. W. Harrington, 1 P.
H. C. Harrison, 1 P.
C. B. Harrop, 1 P., 1 C.
F. A. Harvey, 1 P.
A. V. Henry, 1 P.
L. C. Hewitt, 2 P.
B. M. Hood, 1 P.
R. A. Horning, 1 P., 2 C.
M. R. Hornung, 1 P.
H. A. Huisken, 1 P.
R. K. Hursh, 1 P.
F. G. Jackson, 1 P.
R. W. Jones, 1 P.
R. B. Keeler, 2 P.
S. M. Kier, 2 P.
W. A. King, 1 P.
C. J. Kirk, 1 P.
H. J. Knollman, 3 P.
R. D. Landrum, 1 P., 1 C.
W. K. McAfee, 2 P.
S. J. McDowell, 2 P.
J. M. Mallory, 2 P.
J. M. Manor, 1 P.
P. Marson, 1 P.
H. W. Mauser, Jr., 1 P.
C. R. Minton, 1 P.
D. A. Moulton, 2 P.
W. A. Mudge, 1 P.
F. H. Norton, 1 P.
W. G. Owen, 1 P.
C. W. Parmelee, 1 P.
R. H. Pass, 1 P.
E. P. Poste, 1 P.
W. D. Richardson, 1 P.
F. G. Roberts, 1 P.
W. L. Shearer, 5 P.
Mary G. Sheerer, 2 P.
R. R. Shively, 1 P.
A. Silverman, 5 P., 1 C.
George Simcoe, 1 P.
I. E. Sproat, 1 P.
H. F. Staley, 1 P.
A. Stein, 2 P.
N. Stein, 1 P.
F. L. Steinhoff, 1 P.
E. W. Tillotson, 3 P.
E. J. Unger, 1 P.
E. J. Vachuska, 1 P.
B. F. Wagner, 1 P.
A. S. Walden, 1 C.
P. H. Walker, 1 P.
R. A. Weaver, 5 P.
H. Wilson, 1 P.
H. G. Wolfram, 1 P.
F. C. Woodside, 1 P.
A. S. Zopfi, 1 P., 1 C.
C. B. Young, 1 P.

FOOTNOTE: P = Personal Membership; C = Corporation Membership.

ALLOCATION OF CERAMIC WORK IN FEDERAL BUREAUS

Resolutions

Adopted by the Board of Trustees of the AMERICAN CERAMIC SOCIETY, being an expression of the views of its members based on their understanding of the present allocation of ceramic work in the federal bureaus:

WHEREAS:

1. For purposes of economy and efficiency the Bureau of Mines and the Mineral Resources Division of the U. S. Geological Survey have been transferred from the Department of the Interior to the Department of Commerce; and

2. Both the Bureau of Standards and the Bureau of Mines have extensively equipped ceramic laboratories and have organized ceramic research personnel, each for distinctly different purposes, with different viewpoints and different methods; and

3. The work of the Bureau of Standards primarily is standardization and specification of properties, qualities and form of ceramic materials and products, and simplification in products, which work is extensive in scope and is needed by the industries and is possible of prosecution only in a central national laboratory representing alike the interests of producers and users of ceramic materials and products; and

4. Incidental to the studies on known ceramic materials and products there is need for determinations of fundamental facts and data, which determinations can most effectively be made by those who are working on specifications and standardization and in a central national laboratory such as the Bureau of Standards, where collaboration of investigating scientists in allied lines may readily be obtained; and

5. The Bureau of Mines has laboratory facilities and systems for plant investigations by field stations in the mining, beneficiation and utilization of ceramic minerals and other materials of the earth now used or possible of use, which investigations are of importance to all ceramic industries alike and to the nation's progress generally, because of the use of ceramic products in most of the nation's manufacturing; and

6. The beneficiation and industrial possibilities of ceramic raw materials and especially the finding of materials which will give greater economy in the industries and homes can best be done through field stations, unified and coördinated through a national research organization which represents alike the interests of, and which can work in close coöperation in the field with, the land owners, miners, producers and prospective users; and

7. The distinctive work done by the Bureau of Standards and the Bureau of Mines, with little overlap or duplication, on products and materials respectively, has been kept separate because of the inherent differences in the character of the problems and in the methods and the facilities for making industrial application rather than because of a desire to have two national bureaus engaged in ceramic research; and

8. Work on standardization and specification of products and of the fundamental studies incident thereto by the ceramic division of the Bureau of Standards can most effectively be done in a central laboratory for it does not relate to processing; and

9. The work of the Bureau of Mines has been of such a character that it has been found effective to employ field stations (permanent and temporary) and laboratory cars thus economically, on a production scale, proving in plants of producers and consumers the availability and best methods of using materials; and

10. Empirical or laboratory scale trial production can be trusted only as indicative and rarely as final evidence of the availability and best method of using ceramic materials, hence the type of investigations that have been made by the Bureau of Mines could not have been so successfully made and proved in a central national laboratory; and

11. A single firm or group of manufacturers is not willing alone to finance such development work and plant proving as has been done by, and in coöperation with, the Bureau of Mines except that the information obtained be kept secret and not made available to ceramic manufacturers generally; and

12. There are so many uses of materials and methods of processing which are of equal value directly to all kinds of ceramic manufacturing and indirectly to the manu-

facturers who are dependent on ceramic materials that it is in the interest of national economy and industrial progress generally that a national bureau shall be conducting researches and proving its findings in the field and in the plants and making public the facts discovered; and

13. State universities throughout the nation have provided and to a larger extent will provide buildings, fixed equipment, light, heat, power and maintenance, and will make available the use of their several laboratories which are as diversified and as well equipped as a national central laboratory would be, and these universities make possible the collaboration of scientists and technologists from their instructional and research staffs, and provide graduate student fellowships, which annual expenditure in the case of Ohio State University now amounts to over $10,000; and

14. The maintenance of field stations by the federal government jointly with state universities in districts where ceramic materials occur or where they have the largest probable industrial use is in accordance with Secretary Hoover's idea of encouraging the several states to assume the cost burden of their industrial development and of encouraging the industries to finance more directly their industrial researches; and

15. Stations located at state universities will result in coördination of the ceramic work of the federal bureau and of the university experiment stations thus giving national scope and benefit to ceramic research financed to a large extent by the states and industries;

Therefore, be it resolved:

That the AMERICAN CERAMIC SOCIETY support Secretary Hoover whole heartedly in such of his plans for simplification and economy as do not involve curtailment nor abandonment of the general scope of the ceramic investigations now in progress in the Bureau of Standards and the Bureau of Mines.

To this end the following recommendations are urged for consideration. It is recommended:

First, that the work now being done by the Bureau of Standards on products and that by the Bureau of Mines on materials be continued apart and distinct as separate phases of the ceramic investigations;

Second, that the ceramic laboratories at Columbus and Pittsburgh and the plant and field contacts be continued and enlarged as the work in hand may require;

Third, that facilities be maintained so that the laboratory investigations on ceramic materials may be proved in the field and in industrial plants by Federal Bureau men, as is now being done by the Bureau of Mines; and

Fourth, that simplification and economies in the administration and direction of this work be carried as far as practicable without limiting the type of work now being done and that unification of control be provided so that unnecessary duplication of effort may be avoided, but not to the extent of materially changing the purposes or the character of the investigations now being carried on in both Bureaus.

Be it resolved further:

That copies of these resolutions be sent to Secretary Hoover and that they be published in the *Journal*.

In behalf of the Board of Trustees,

E. WARD TILLOTSON, *President*.

LOCAL SECTION NEWS

Baltimore-Washington Section, Dec. 5[1]

The second meeting for the 1925–26 season of The Baltimore-Washington Section of the AMERICAN CERAMIC SOCIETY will be held in Washington on Saturday, Dec. 5, 1925.

The meeting will open at 3:00 P.M., at room 237 Industrial Building, Bureau of Standards, where an inspection trip will be made of the industrial laboratories of the Bureau. Following the visit to the Bureau, the regular dinner will be served at 6 o'clock at the Lee House, 15th and M Streets, N. W., after which Dr. Brown, Assistant Director of the Bureau of Standards, will address the meeting.

Chicago Section, Dec. 10[2]

The officers of the Chicago Section announce that a meeting of the Section is being planned for Thursday evening, December 10, and is to be held in the rooms of the Chicago Engineers' Club, 314 South Federal Street, Chicago. It will begin with a dinner at 6:30 P.M., after which a very interesting program will be presented.

W. A. Darrah, who will be remembered as having presented a very interesting paper at Columbus on "The Vitreous Sanitary Ware Industry" will present a paper which will be of particular interest to enamelers inasmuch as it will deal with furnace installation for such. His paper will be illustrated by slides.

In addition to Mr. Darrah's presentation there will be others and, although this notice is addressed to members of the SOCIETY, we want anyone in any way connected with the ceramic industry to feel that this invitation is extended to them, also.

Meeting of the St. Louis Section, Nov. 6[3]

The meeting of the St. Louis Section was held at this time to take advantage of obtaining speakers from the National Brick Manufacturers Association who were assembled in St. Louis for their annual meeting. F. E. Bausch, Chairman, called the meeting to order.

A. V. Henry, Head of the Department of Ceramics, Georgia School of Technology, and B. M. Hood, of Atlanta, Georgia, were the chief speakers of the evening. Dr. Henry treated on the function of the technical ceramic schools and dealt in particular with the establishment of a Ceramic School in Missouri, what such a school would mean to the industry of the state and how it should be organized. Dr. Henry brought out the advantages of a school located at an institution such as Washington University which is an endowed one, as compared to a location at a State School, such as Rolla, which is dependent upon legislative appropriation. Further emphasis was placed upon the advisability of the ceramic school being located in the heart of the industry such as St. Louis is.

Following Dr. Henry's talk, round table discussion was held, a great many participating in this discussion. A number of graduates from Rolla were present and they dealt upon the advantages of a ceramic school in conjunction with an institution which teaches mining and metallurgy.

Prof. McCourt, Dean of the Engineering School, Washington University, was also present and spoke of the work of the University, and of their willingness to coöperate to

[1] D. H. Fuller, Secy.

[2] W. V. Knowles, *Chairman*.

[3] L. C. Hewitt, Secy.

the fullest extent in any movement that might result in the establishment of a ceramic course.

Mr. Hood gave a particularly interesting and instructive review of the possibilities of the ceramic industry in the South, also relating the means that were used in securing a Ceramic School for Georgia. Mr. Hood has a wide number of interests in the clay working industry in that State, and is the man who is responsible for bringing about the establishment of the Ceramic course at the Georgia School of Technology.

We were also fortunate in having with us at this meeting Jacob Stocke, Jr., President of the National Brick Manufacturers Association, J. W. Sibley, Treasurer, and Theo. A. Randall, Secretary. These gentlemen expressed their desire to coöperate in every way possible with the AMERICAN CERAMIC SOCIETY, bringing out the point that the men in all lines of the ceramic industry did have mutual problems.

H. A. Wheeler replied in behalf of the Local Section expressing the hope that the AMERICAN CERAMIC SOCIETY and the National Brick Manufacturers Association would again resume their policy of meeting at the same time in the same city at least every other year. Mr. Wheeler also related some points relative to the formation of the AMERICAN CERAMIC SOCIETY, bringing out the fact that the National Brick Manufacturers Association is, in reality, the parent organization.

At the close of our meeting a rising vote of thanks was given to Mr. Hood and Dr. Henry for their coöperation.

There were 34 present at the meeting, consisting of 15 visitors and 19 members, as follows:

VISITORS

H. C. Penfield, Bowery Savings Bk., N. Y. City
W. T. Bussell, Brazil, Ind.
A. P. Potts, Brazil, Ind.
A. V. Henry, Atlanta, Ga.
W. F. Demuth, New Philadelphia, Ohio
E. C. Enler, South Milwaukee, Wis.
J. R. Grout, Jr., Danville, Ill.
J. R. Green, Indianapolis, Ind.
F. M. Poole, Tulsa, Okla.
W. H. Merkel, Kansas City, Mo.
W. J. Becker, St. Louis, Mo.
B. M. Hood, Atlanta, Ga.
Mr. Kraus, Philadelphia, Pa.
M. W. Blair, Terra Haute, Ind.
Prof. McCourt, St. Louis, Mo.

MEMBERS (St. Louis Local Section)

C. B. Kentnor, Jr.
M. Epstein
J. B. Lyon
A. W. Buckingham
A. F. H. Seelig
H. A. Wheeler
W. D. Thompson
L. H. Blue
John W. Rogers
August Vollmer, Jr.
H. W. Weber
C. S. Haupt
W. H. Weber
Miss M. Regnier
F. E. Bausch
R. C. Gosreau
F. S. Markert
E. O. McFadden
L. C. Hewitt

PERSONAL NOTES

R. L. Frink who has recently been located in Dairen, Manchuria, with the South Manchurian Railway Co., has returned to Lancaster, Ohio.

J. R. Green has moved from Evanston, Ill., to 215 E. New York St., Indianapolis, Ind.

F. P. Hall, formerly at the Massachusetts Institute of Technology, has recently become associated with the Standard Oil Co. of New York City as Research Chemist.

J. B. Krak, Technical Editor of *The Glass Industry,* Jamaica, N. Y., has removed to 334 First St., Niagara Falls, N. Y.

James W. Moncrieff has moved from Stockton, Calif., to 1812 Pearl St., Alameda, Calif.

A. Nugent Ragland who has been associated with the Perth Amboy Tile Co., Perth Amboy, N. J., has moved to 2232 Sherman Ave., Evanston, Ill.

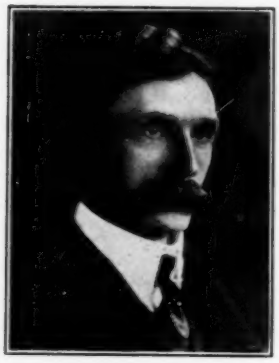
NOTES AND NEWS

ST. LOUIS ENAMELERS' CLUB

A meeting of the St. Louis District Enamelers' Club was held at Belleville, Ill., Nov. 24, 1925. Twenty-one members were present.

Adam Karr of the Karr Range Company of Belleville gave an interesting account of his recent trip through Europe where he spent three months. Mr. McFadden of the same Company read an excellent paper on spraying.

The officers of this Club are C. S. Haupt, President, E. A. Eigenbrot, Secy.-Treasurer and A. E. Krebs, Vice-president.



J. A. HOLMES

THE BEGINNING OF CERAMIC INVESTIGATION BY FEDERAL GOVERNMENT

Credit for the first special division in a federal bureau belongs very largely to J. A. Holmes, the first director of the Bureau of Mines. He engineered the legislative bill and made provisions for carrying into effect the proposals contained in resolutions adopted and championed by the AMERICAN CERAMIC SOCIETY. We are pleased to have the privilege of acknowledging the obligations of ceramic people generally to Dr. Holmes.

DR. TURNER, NEW DIRECTOR OF BUREAU OF MINES

Scott Turner, of Lansing, Michigan, was recently appointed director of the federal Bureau of Mines to succeed H. Foster Bain, now Secretary of American Institute of Mining and Metallurgical Engineers. Dr. Turner is a mining engineer of international reputation. He received his A.B. degree from the University of Michigan in 1902 and his B.S. and E.M. from the Michigan College of Mines in 1904. For many years Dr. Turner held positions in milling and mining companies in the western states, as assayer, examining engineer and field work. For a short while he was assistant editor with T. A. Rickard of *Mining and Scientific Press* of San Francisco.

From 1905–06 Dr. Turner was superintendent of the San Pablo Gold Mining Co., and Pontiac-Panama Co., Province of Veraguas, Panama, and in 1908 he was associated with T. A. Rickard in Dawson, Fairbanks and Nome, Alaska. In 1911 he was directing field work in tin mines at Cornwall, England, and 1914 located in Spitsbergen in field work for J. M. Longyear of Boston. From 1911–16 he was agent for the Arctic Steamship Co., and during the two years succeeding he was in charge of field work in Peru, Bolivia and Chile. In 1919 he became construction engineer for the Mining Corporation in Canada (Toronto) and in 1921 he became associated with the U. S. Bureau of Mines as construction engineer.

For five years Dr. Turner opened and operated coal mines at 79° 13′ N. Lat. on the Island of Spitsbergen. This island is 825 miles north of the Arctic Circle on No Mans Land. Here he claimed and maintained possession of 600 square miles under the protection of the American flag.

He is the author of many articles for the technical press. During the War he served as military lieutenant, senior grade, U. S. N. R. F., April, 1918 to January, 1919. He is a survivor of the S. S. Lusitania which was sunk by a German submarine on May 5, 1915. Dr. Turner is a member of the American Institute of Mining and Metallurgical Engineers and the Canadian Institute of Mining and Metallurgy.

PROGRAM OF SECOND ANNUAL MEETING

Ohio Ceramic Industries Association

(November 20 and 21, 1925)

Friday Afternoon—November 20—1:00 P.M.

"The Ceramic School at East Liverpool," by Kenneth Smith.

"Ceramic Extension Service for Ohio," by Arthur S. Watts.

"The Organization of Agricultural Engineering Research through the Federal and State Agencies," by Professor G. W. McCuen, Ohio State Agricultural Engineering Department.

"The Coöperative Policies of the State Board for Vocational Education," by E. L. Heusch.

Saturday Morning—November 21—9:00 A.M.

"The Reorganization of Ceramic Research under the Federal Government and What It Means to the Ohio Industries," by R. C. Purdy.

"The Utilization of State Facilities by the Ceramic Industries," by A. V. Bleininger.

"The Necessity for Organized Plans by the Ceramic Industry before the State Can Provide Coöperative Aid," by Dean E. A. Hitchcock, College of Engineering, Ohio State University.

JAPANESE CERAMIC SOCIETY

By S. Kondo

The growth of the Japanese Ceramic Society was retarded not only by the War but by the earthquake in the Tokio district in 1923.

This Society, however, is showing a slow but steady progress in the quality of the contents of the Journals.

The officers have exerted themselves to the utmost for maintaining its status quo, also for its expansion in coming years. Open lecture-meetings were held every year in spring and autumn by its head-office in Tokio as well as its branches in Kioto, Osaka and Nagoya. The Standing Committee is now planning the third ceramic exhibition which will be held for three weeks in December in Tokio.

The management of the Society is vested in the Standing Committees with three Directors, who are elected every year by the members of the Society. At present, O. Umeda is the Chief-director, K. Ishikawa,

Kentaro Kaneko

the Vice-Chief-director and S. Kondo the Director of Editing. Chief-directors in recent years were: 1922, J. Kumazawa, 1923, S. Kondo and 1924, R. Shibata. Vice-Count K. Kaneko, former Minister of Agriculture and Commerce and now a Privy Councillor, has long been elected the President.

The membership figures follow:

	Honorary	Supporting	Ordinary	Total
March 31, 1922	5	14	1376	1395
March 31, 1923	5	18	1406	1429
March 31, 1924	5	18	1374	1397
March 31, 1925	4	18	1358	1380

NOTES FROM CERAMIC SCHOOLS

ALFRED UNIVERSITY

By C. F. Binns

The registration at Alfred this year reflects not only the large increase in enrollment experienced by nearly all colleges this fall but evidently a special interest in the subject of ceramics as demonstrated by the large number in the entering class. The registration figures follow:

	Men	Women	Total
Graduates	1	0	1
Seniors	7	9	16
Juniors	21	10	31
Sophomores	24	7	31
Freshmen	58	10	68
Specials	3	1	4
Totals	114	37	151

The ceramics school building, designed for 80 to 100 students, has been crowded to capacity the last few years notwithstanding the fact that the Department of Chemistry was forced to move to one of the college buildings so as to leave the space for laboratory work in ceramics. With 151 students now taking ceramic courses conditions are such that an immediate addition to the building is absolutely necessary.

The New York State Legislature has been asked for three years to grant an appropriation of $60,000 for building and $15,000 for additional equipment. Their refusal means that a limitation must be placed on the enrollment. There has been no increase in the faculty although the number of students continues to grow greater every year.

Arthur H. Radasch

Arthur H. Radasch Arthur H. Radasch, who has been appointed to succeed A. I. Andrews as Professor of Ceramic Engineering at Alfred University, graduated from the Massachusetts Institute of Technology with the degree of Bachelor of Science in Chemical Engineering. From 1920 to 1921 he was instructor of Industrial Chemistry and Chemical Engineering at Harvard College and North-

eastern College and was also connected with the Division of Industrial Coöperation and Research at M. I. T. In the summer of 1921 he was an instructor in Industrial Chemistry at Massachusetts Institute of Technology. In the fall of 1921 he came to Alfred as Professor of Chemistry in the New York State School of Clay Working and Ceramics. He has therefore had four years of association with this school before assuming his present duties.

Donald W. McArdle Graduate of M. I. T., 1918, S.B. in Chemistry. Graduate of Lowell Institute 1922 (Mech. Eng.). Two years graduate work M. I. T. (Chem. Eng.). After four years in chemical manufactories, spent three years at Boston University as instructor and assistant professor and is now located at Alfred.

GEORGIA SCHOOL OF TECHNOLOGY

By A. V. Henry

The Department of Ceramics, Georgia School of Technology, has entered its second year with two students in their junior year and ten in their sophomore year.

Since it was felt that any engineering department must have the coöperation of the industry to gain maximum success, a Coöperative Course in Ceramics is being given this year in addition to the regular four year course. Ten students are enrolled. In this course, a student alternates monthly in the school and a particular ceramic industry. Indications are that the Coöperative Course will be given enthusiastic support by the southern ceramic manufacturers.

During the past year the Department entered into a coöperative agreement with the Central of Georgia Railway to further study the sedimentary kaolins of Georgia. Two major subjects are being investigated, the first of which is "The Refining and Blending of the Sedimentary Kaolins of Georgia" and the second, "The Use of Georgia Clays in Saggers." The investigation is expected to continue for at least one year. W. H. Vaughan who received his degree of Master of Science in the Ceramics Department, University of Illinois last year is now engaged in this work.

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

By S. W. Stratton

It has been announced that a course in Ceramic Engineering will be introduced at the Massachusetts Institute of Technology at the beginning of the next academic year. The personnel is being selected and provisions are being made for housing and general equipment.

IOWA STATE COLLEGE

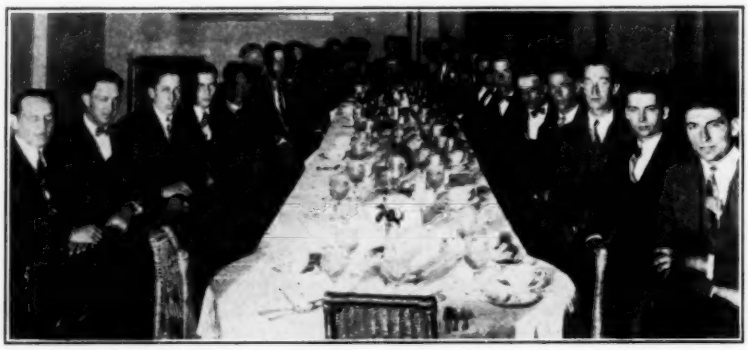
By Paul E. Cox

The Department of Ceramic Engineering at Iowa State College has 30 men enrolled for the four year course and additionally handles the ceramic engineering work for 50 young women who work in modeled pottery in the department under the direction of Miss Mary L. Yancey. These young women are enrolled in other departments of the College.

At Ames nearly all ceramic engineers are converts from other departments, so that we have one freshman and one graduate student, with 28 others in between, 7 of them being seniors. Most preps have never heard of ceramics and so come for radio. The

freshman year is planned to be elastic enough to allow a change of course without loss to the student.

There are no new facilities of any importance for teaching work though a group of senior students are working on special problems and two or three small bits of equipment have been built from their ideas. These jobs are interesting because they are initiative developers.



All Ames graduates from the department write of enjoyment in ceramic work, and one man came in and spent the time here rubbing it in on his brother who is engaged in teaching electrical engineering. The ceramic man is working in enameled metal and twits his brother by telling him that in ten years the ceramic graduate can expect to be ready to start his own plant while the electrical engineer may expect to still have a salaried job with a corporation in the same time. Lately the department placed a man from another department since no ceramic men were available.

NORTH CAROLINA STATE COLLEGE

By A. F. Greaves-Walker

I. General 1. Students registered for 1925–26: 10 freshmen, 9 sophomores, 1 junior.

2. The appointment of George R. Shelton as assistant Professor of Ceramic Engineering has already been announced in the *Bulletin*.

The new ceramics building will probably not be completed until the latter part of the winter term, although the classrooms, office and chemical laboratory will be ready for occupancy in about 30 days. Much of the equipment is on hand or arriving. At least half of this equipment, while useful for the students' laboratory work, is to be devoted primarily to research and experimental work in connection with the development of the ceramic industries in North Carolina and in the South.

3. The Department is carrying on a coöperative research project with the North Carolina Department of Conservation and Development to determine the commercial value of the shales of North Carolina. The Department of Conservation and Development is carrying on the geological end of the project.

4. The research projects in progress are:

(*a*) A study of the structural clay products plants of North Carolina to determine the improvements that can be made in product and equipment. This project has been under way for a year and is almost completed.

(*b*) A study of North Carolina to determine its shale resources and the determination of the commercial uses to which the shales can be put.

(*c*) The investigation of the pyrophyllite deposits of North Carolina to determine their value for refractories manufacture.

5. A student branch of the AMERICAN CERAMIC SOCIETY is holding monthly meetings in which a great deal of interest is being taken.

II. Short Course in Clayworking and Ceramics

The department of Ceramic Engineering at North Carolina State College, Raleigh, N. C., announces the second annual Short Course in Clayworking and Ceramics, which will be given at the College, January 18th to 27th, 1926, inclusive.

The course has been increased in scope and will this year cover nine days instead of six as was the case last year. Lectures will be given in the following subjects, by members of the faculty of the departments of Ceramic Engineering, Mechanical Engineering, Electrical Engineering, Architectural Engineering and Business Administration.

1. Chemistry of Clays
2. Origin and Properties of Clays
3. Prospecting and Sampling
4. Mining of Clays
5. Dies and Auger Machines
6. Driers and Drying
7. Kilns and Firing
8. Fuel and Fuel Economy
9. Steam and Steam Power
10. Boiler Feed Water
11. Electric Motors and Their Uses
12. Care and Maintenance of Machinery
13. Business Principles
14. The Use of Brick in Buildings.

The course deals with the principles underlying the work of managers, superintendents, foremen, burners and others engaged in the brick, hollow tile and sewer pipe industries. A common school education will suffice as preparation for the course.

Last year thirty students representing nineteen states enrolled in the course. A larger enrollment is expected this year. The new Ceramics Building at the College will in all probability be completed before the course opens.

The course will be open to all those interested, whether residents of North Carolina or not. No fee will be charged. A bulletin covering the course will be issued in December and will be sent on request.

III. Correspondence Course for Enamelists

A. F. Greaves-Walker of the North Carolina State College, Raleigh, N. C., announces that a new correspondence course in Ceramic Engineering designated as Cer. E. 210A, "Enamels and Enameling," is now ready. This course covers the subject of enameling on iron and steel in a very thorough manner and is designed especially to give technical training to the non-technical enamelist in simplified terms and formulas.

The course begins with an assignment of the chemical terms and the chemistry of the industry, which is followed by assignments on raw materials; calculation of melted weights and percentage composition; classification of enamels for cast iron; classification of enamels for sheet steel; coefficients of expansion of enamels; chipping, crazing, fish scaling; method of calculating coefficients of expansion; relation between chemical composition and physical properties; mixing, melting, drying and grinding apparatus; preparation of iron and steel and types of furnaces.

The course will be under the supervision of George Reed Shelton of the Ceramic Engineering faculty. The registration fee is $7.50. Three college credits are granted upon satisfactory completion of the course.

Bulletin and registration blanks may be obtained by addressing Frank Capps, Director of College Extension, North Carolina State College, Raleigh, N. C.

OHIO STATE UNIVERSITY

By A. S. Watts

Registration 1925–26, according to College of Engineering records, 19 seniors, 27 juniors, 45 sophomores, 37 freshmen (up to October 15).

Note: Freshmen do not choose any department except by voluntary announcement, until the end of the first year.

New Teaching Facilities

Samuel R. Scholes becomes a member of the faculty and will teach a special course in fine ceramics, dealing especially with glass, as a portion of the senior laboratory assignment.

The department has obtained new equipment consisting of a Palo Furnace, new ball mill room equipment for twelve men and new locker equipment for 20 men. The new humidity control drier installed by Proctor and Schwartz Company will make it possible to conduct investigations in problems of drying not heretofore possible.

F. C. Westendick

Three post graduate researches are in progress having the following subjects:

1. "Further Study of the Heat of Summation of Ceramic Bodies." (Coöperation with Bureau of Mines.)
2. "Eutectic Study of the Alkali and Lead Barrow Silicates and Alumina."
3. "The Influence of Composition on the Specific Gravity of Some Industrial Glasses."

Frank Westendick

Mr. Westendick, instructor in the Department of Ceramics, was born at Louisville, Ky., 1891. He followed the electrical profession until 1911 from which time until 1923 he was associated with social service work. He entered at Ohio State University in 1920 and was graduated from Ceramic Engineering College in 1925, where he was student assistant during 1924–25. He worked for the National Fire Proofing Co. on drier trouble during the summer of 1924 and worked for the Windsor Brick Co. on gas firing problems during summer of 1925.

PENNSYLVANIA STATE COLLEGE

By J. B. Shaw

This department has started the year 1925–26 with a total registration of 18, subdivided as follows: seniors 1, juniors 6, sophomores 7 and freshmen 4. One instructor was added to the department, Walter A. Preische, graduate of Alfred University to be employed in this capacity. The equipment has been materially increased by construction of furnaces and purchase of considerable apparatus required in the department. The equipment at present is considered entirely adequate although, of course, if funds were available much more elaborate equipment might be installed.

The department has been under some slight disadvantage owing to the fact that natural gas is not available for laboratory use but after some considerable experimenting it was found that this disadvantage has been entirely overcome and results are now being obtained with oil fuel as satisfactorily as can be obtained with natural gas. It has been

found that the difficulty incurred in using oil fuel results from the failure to filter properly the fuel, or the use of a low grade of fuel. The department at present is using kerosene oil which would be too expensive for commercial purposes but the difference in cost is negligible for the amount used in the laboratory and if furnaces are properly constructed and the equipment rightly controlled there is no difficulty in obtaining most any kind of furnace condition as regards oxidation or reduction of temperature that is desired.

The Pennsylvania State Geology department and George H. Ashley have outlined a program to make a complete survey of the clays of the state. This work has been placed under the direct supervision of J. B. Shaw, Head of the Department of Ceramics at Penn State. Samples are now being collected which will subsequently be tested in the laboratory of the department. The work has been started on fire clay with particular attention being paid to flint fire clay. It is expected that this portion of the work will be completed within a year.

The department of ceramics is meeting with enthusiastic support on the part of the manufacturers of the state which augurs well for its success. Numerous trips are taken by the students to manufacturing establishments where the students are given an opportunity to tie in the practical side of ceramics with the technical work which they receive in the department.

The department at Penn State is taking full cognizance of the discussion now being carried on as a result of the efforts of the Committee of Education of the AMERICAN CERAMIC SOCIETY and while no new courses are being added at present the work in the courses as listed is being somewhat modified with a view to laying more stress on Ceramic products than heretofore. It is felt, however, that the present curriculum at Penn State already recognizes the importance of the subject under discussion and in fact much of the work deals with properties, uses and testing of ceramic products.

RUTGERS UNIVERSITY

BY GEORGE H. BROWN

There are twenty-seven students enrolled in the Ceramics course at the present time. Walter L. Shearer, who has been associated with the department since 1923 in the capacity of instructor and research assistant, has been appointed Assistant Professor of Ceramics. Geo. C. Betz, formerly with the New Jersey Terra Cotta Company, has been added to the staff in the capacity of Instructor and Research Assistant, while Wilbur R. Wyckoff, a graduate of the class of 1925, is serving as a research assistant.

The department is coöperating with the various ceramic plants in the State in the solution of their manufacturing problems. A new apparatus has been assembled and is being used in the measurement of the coefficients of expansion of refractory and other ceramic materials. Research work is being done with a view to ascertaining the value of p_H determinations in the control of casting slips. A series of experiments in the use of Cornwall stone in vitreous bodies is now under way.

The Rutgers Ceramics Club and Student Branch of the AMERICAN CERAMIC SOCIETY is holding regular monthly meetings. At the meeting on October 8, 1925, the following officers were elected for the 1925–26 season. President, Leonard Hepner; Vice-President, D. Koch; Treasurer, G. Danskin; Secretary, John R. Kauffman. Leslie Brown of Lenox, Inc., Trenton, N. J., will address the Club on November 19th on the "Manufacture of Lenox Ware." His talk will be illustrated by a moving picture showing the processes of manufacture in detail. The Club has arranged to have talks by prominent ceramic men at each meeting.

Recent graduates of the Ceramics Department at Rutgers University are employed in the following plants:

Fraser B. Rhodes, Robertson Art Tile Co., Trenton, N. J.

Geo. T. Morse, Enterprise White Clay Co., Philadelphia, Pa.

N. Johnson Kent, The Johns-Manville Co., Manville, N. J.

S. Habas, Instructor, Dept. of Chemistry, Rutgers University, New Brunswick, N. J.

M. B. Catlin, investigative work in German ceramic plants.

J. A. Plusch, inspector on tile for new Holland Vehicular Tunnel, Plant of American Encaustic Tiling Co., Zanesville, Ohio.

Clinton R. Kennaday, Woodbridge Ceramic Corp., Woodbridge, N. J.

L. R. Squier, New Jersey Terra Cotta Co., Perth Amboy, N. J.

H. T. Cunningham, The Carborundum Co., Perth Amboy, N. J.

Rodney T. Rouse, Golding Sons Co., Trenton, N. J.

C. Edwin Prentice, Sayre & Fisher Co., Sayreville, N. J.

UNIVERSITY OF ILLINOIS

By C. W. Parmelee

The eighty-eight who are registered in ceramics at the University of Illinois, 1925–26 may be classified as follows:

Seniors	12
Juniors	21
Sophomores	27
Freshmen	25
Graduate	3
Total	88

New teaching and experimental facilities secured this year are (1) three furnaces given to the department by the Illinois Gas Manufacturers Association, (2) Carrier Ejector Processing Cabinet and (3) Grinnell Drier.

Coöperative research is being conducted on (1) electrical porcelain and (2) power plant refractories and gas machine refractories. This research is carried on with certain utilities companies of North Illinois and this department.

Other research problems in progress at this time are (1) An investigation of firing conduct of certain Illinois shales, (2) An investigation of hard finish plaster, (3) An investigation of drying of clay ware.

Our graduates of June, 1925 are located with the following firms:

Abney, Charles L., Columbus Brick and Tile Co., Columbus, Ga.

Bopp, Harold F., 305 Main St., Dundee, Ill.

Bradley, Richard S., A. P. Green Fire Brick Co., Mexico, Mo.

Fels, Clarence G., Atlanta Terra Cotta Co., Perth Amboy, N. J.

Foster, Edwin S., 1090 Peralta Ave., Berkeley, Calif., N. Clarks and Sons.

Grigsby, Chester E., Department of Ceramic Engineering, University of Illinois, Urbana, Ill., Refractories Research.

Grout, Jack R., Jr., Acme Brick Co., Danville, Ill.

Halloin, William G.

Innes, David H., Zwerman Company, Robinson, Ill.

Lampe, Chester E.

McNair, Francis G., 75 N. Batavia Ave., Batavia, Ill.

Parmelee, C. Everett, Pittsburgh Plate Glass Co., Crystal City, Mo.

Schroeder, George C.

Vaughan, W. Harry, M. S. in Ceramic Engineering, Georgia School of Technology, Atlanta, Ga.

Whitney, W. Percy., Lancaster Brick Co., Lancaster, Pa.

Short Course in Ceramics to be Given in January

The University of Illinois announces a Short Course in Clay Working and Enameling to be given January 11 to 23, 1926.

The course is designed to meet the requirements of practical men. It will deal with the principles underlying the work of managers, superintendents, foremen, burners and others who may be concerned with the manufacture of ceramic products.

A common school education will suffice as preparation for the course. No fees are required, but a contribution of one dollar toward the expense of printing leaflets necessary in certain courses is to be made by each person upon registration.

The course of instruction will include lectures, laboratory work and informal discussions. Besides the members of the staff of the Dept. of Ceramic Engineering and members of the Engineering and other faculties of the University of Illinois, it is expected that M. C. Booze of Mellon Institute, Pittsburgh, Pa., R. R. Danielson of the A J. Lindemann and Hoverson Co., Milwaukee, Wis., and A. S. Watts, Head of the Dept. of Ceramic Engineering of Ohio State University, will assist.

Programs may be had upon application to the Department of Ceramic Engineering, University of Illinois.

UNIVERSITY OF SASKATCHEWAN

By W. G. Worcester

We have four students in the third year, none in the fourth year and as to how many in the first and second years we have no means of knowing, owing to the fact that they do not register as ceramic students until the beginning of their third year.

As to new teaching and experimental facilities, I am pleased to say that our new quarters are rapidly nearing completion. We expect to be in them by the first of the year and will have at our command twice the space we formerly had as well as much new equipment that we could not place in the old quarters owing to lack of space.

We are not conducting any research work largely in that the time of the department and myself is being taken up with the solving of industrial problems and in the assisting of new development as well as conducting a survey of the Saskatchewan ceramic materials.

As to our graduates, I am pleased to state that our first men turned out are holding positions, one with the Evens and Howard Refractories Plant at St. Louis and the other with the Ontario Sewer Pipe Company at Toronto. Both men I am told are doing very well.

UNIVERSITY OF TORONTO

By R. J. Montgomery

The ceramic work here is open to 4th year students as an option in the School of Applied Science. The students taking the work this year give about three-quarters of their time to it, including their thesis. We are hoping next year to extend the work to go beyond the one year, as it is rather difficult to cover general lectures and advanced labo-

ratory work the same year. Three students are registered this year. Two of them are 4th year chemical engineers, specializing in ceramics. The third man is in the graduate school, having graduated last year in geology and specializing this year in nonmetallic minerals.

In regard to equipment, we are gradually getting together the usual laboratory outfit; nothing special so far has been obtained.

In regard to coöperative research and other departmental work, we are hardly far enough along yet to be doing anything along that line. The local clay manufacturers are submitting samples for our study, and that is about as far as we have gone as yet.

These notes are rather meager, but a new department cannot furnish very much. I hope that next year we will have more activities to report upon.

UNIVERSITY OF WEST VIRGINIA

W. A. KOEHLER

W. A. Koehler W. A. Koehler was appointed head of the Ceramics Division of the Chemical Engineering Department at the University of West Virginia, Morgantown, W. Va., in 1924. Dr. Koehler received his B.S. degree in Chemical Engineering at the University of Wisconsin in 1919 and the following year was assistant in that department. During 1920–21 he was research chemist with the Carborundum Company and 1922 took his master's degree in ceramic chemistry at the University of Illinois where he was a scholar. He received a scholarship at the University of Wisconsin where he studied colloid chemistry under Svedberg and took his Ph.D. in physical chemistry in 1924. Dr. Koehler states that West Virginia offers a large field for technically trained men in ceramic lines. "The state contains 80 glass plants employing 14,760 people; 21 potteries employing 4600 people; with 1300 distributed among enameling plants, brickyards and structural tile plants."

UNIVERSITY OF WASHINGTON

BY HEWITT WILSON

The department of ceramic engineering at the University of Washington, Seattle has 6 major students in ceramics and 4 minors. The minors are those who will get their degree in other departments but are taking practically all the ceramic courses. Of this group of 10, 5 are graduate students, 4 are seniors and one is a junior.

We have our usual coöperative research work in progress with the Northwest Experiment Station of the U. S. Bureau of Mines. The subject of investigation this year is a study of the whiteware materials of the Pacific Northwest, including the kaolins of Eastern Washington and the feldspars from various sources. Roland Clark, one of the Bureau of Mines fellowship men and a graduate of the New York School of Ceramics, is designing and operating a new type of clay washing apparatus for the purification of these white firing clays.

Hewitt C. Fearn, graduate student from Columbia University and holder of a Bureau of Mines fellowship, is designing a humidity drier for research work with the clays of southwest Washington which have been giving trouble in drying.

Henry N. Baumann, graduate student from the University of Washington and holder of the third Bureau of Mines fellowship is working with Thomas E. Nicholson, senior, in testing the efficiency and obtaining a heat balance for wood fired periodic kilns, coal fired Hoffman continuous kilns, terra cotta muffle kilns and sewer pipe kilns.

Hobart R. Goodrich, senior, is developing a spalling test for fire clay brick using the loss in strength after thermal shock as the indicator. Thad O. Smith, senior, is testing local sands and quartz rocks for possible glass sands.

Other research work which is being carried on in the department includes the development of a test for plaster of Paris (pottery molding plaster), and some experiments in coöperation with the Pacific Northwest Section of the Common Brick Manufacturers Association to eliminate the scumming effect of the gypsum in Portland cement mortars for brickwork.

CERAMIC NIGHT SCHOOL AT EAST LIVERPOOL

Registration for the East Liverpool Ceramic Night School opened on Monday evening, November 26. Kenneth M. Smith, Director, is to be in charge of this work and talks were made by A. V. Bleininger of the Homer-Laughlin China Co., Newell, W. Va., and E. L. Heusch, State Superintendent of vocational training.

An outline of the course includes practical studies such as mechanical drawing, shop arithmetic, physics, chemistry and ceramics.

The subjects are presented in a simplified form so as to make them readily understandable to the potter or student who may not have had any previous training in these branches. Progress will be made slowly so as to give each registered student opportunity to lay satisfactory foundations in his work. The members of the teaching corps from Director Smith down, wish to have it emphasized that they will be there to help and not to embarrass anybody; and therefore they respectfully request any workman in the shop who is ambitious to increase his knowledge respecting the theoretical or practical sides of the ceramic industry to register. The first course will run for twelve weeks.

DR. BINNS LECTURES AT METROPOLITAN

Charles Fergus Binns, Director of Ceramics at Alfred University is engaged in a series of lectures on pottery at the Metropolitan Museum of Art. Four of these were presented in November on (1) Nature and properties of clay, (2) The shaping of clay ware from fluid, plastic and semi-dry material, (3) Kilns and firing, (4) Glazes and glazing.

The remaining two lectures will be given on December 4 and 11, respectively, the first on "Technical Types as Illustrated by Museum Specimens—Low Temperature Ware, Earthenware Faience." The final lecture will be "Technical Types as Illustrated by Museum Specimens—High Temperatures—Stoneware and Porcelain."

This series is presented under the auspices of the Arthur Gillender lectures.

W. E. S. TURNER HONORED BY THE GLASS INDUSTRY[1]

An honor which will give pleasure to University colleagues and other friends in Sheffield, and to glassworkers throughout the country, has been conferred on Professor

[1] From the Sheffield Daily Telegraph, Oct. 19, 1925.

W. E. S. Turner of the University of Sheffield. In recognition of his services to the glass industry, Professor Turner has been made on honorary freeman of the Worshipful Company of Glass Sellers of the City of London.

Professor Turner is the head of the Department of Glass Technology at Sheffield University. He was appointed to that position when the department was founded in 1915, and has thrown himself with great energy and success into the development of the work, which has been of much value to the glass industry. He also took the leading part in the establishment of the Society of Glass Technology, of which he was at first secretary and has since been president.

Last May the Court of the Company of Glass Sellers paid a visit to the Department of Glass Technology and the link which binds them to Sheffield will be strengthened by the admission of Dr. Turner to their freedom. The honor was conferred upon him at a meeting of the Court. Subsequently, he and Mrs. Turner were among the guests at the dinner to the Lord Mayor and Sheriffs in the Carpenters' hall, and the Prime Warden of the Company in his speech made a reference to the work which Professor Turner was doing at the Department of Glass Technology.

SOCIETY OF GLASS TECHNOLOGY

The first meeting of the Society of Glass Technology for the Session 1925–26, was held in Sheffield on October 21, when the President, T. C. Moorshead, delivered his Presidential Address on "The Glass Bottle Industry and Its Future Developments."

At the outset Mr. Moorshead pointed out that the comparative lack of definite knowledge of the structure and characteristics of glass and the means of controlling its manipulation with absolute certainty had to a large extent retarded the development of the mechanical phases of the industry. Yet the last quarter of a century had seen practically a complete revolution in the manufacture of glass containers, and this period formed one of the most important epochs in the history of the glass bottle industry, economically, scientifically and commercially.

About 1900 two ideas, totally different in principle, suddenly blossomed forth. One was Homer Brooke's idea of feeding a machine with a stream of glass flowing by gravity from the furnace, the other was the application of the suction principle in feeding the machine, a process developed by M. J. Owens. From this time progress in the development of mechanical devices for glass manufacture had been rapid. With the development of automatic processes there had come a very great improvement in the character of all of the auxiliary plant and equipment, with the result that today many bottle manufacturing plants were practically mechanically operated throughout.

Future developments in the gravity process and in the suction process depended on different factors. The success of the suction process lay in its application to mass production, but it was not economically adaptable to the smaller units. With the gravity flow process it should be possible, on account of the comparatively simple auxiliary plant required for feeding, to produce articles more economically and at the same time to obtain the desired flexibility of operation.

After dealing briefly with leers, including "heatless" leers, Mr. Moorshead went on to discuss furnace design, a subject which had been very much neglected. Properly coördinated research work, exploring the problem thoroughly, would no doubt be rewarded with valuable information. In the firm belief in the feasibility of the principle of feeding and melting the batch at the same time and with a view to blazing the trail for future and more extensive research work, the United Glass Bottle Manufacturers, Ltd., were arranging to finance some experimental work based on the principles outlined

by Alex. Ferguson and described to the Society of Glass Technology in May, 1923. Details of the proposed experiments were given; the theoretical advantages claimed for the new process being (1) Smaller radiating surface per ton of furnace melting capacity, the ratio being approximately 2:1. (2) More intimate contact between the flame and the constituents of the batch. The first mentioned, however, depended upon (*a*) the feasibility of melting the batch, when pulverized and fed into the furnace in fine powder in the short time of passage through the flame; (*b*) the corrosive effects of the stream of melted glass on the side walls of the funnel shaped melting chamber, as well as the effect on the glass itself. In conclusion, the mechanical development of the bottle industry in the past 20 years had been little short of marvellous, and in mechanical efficiency was probably not surpassed by any other manufacturing industry. Nevertheless, still further research was necessary to discover a formula from characteristics other than that with which they had to deal today. Further knowledge of the mechanical properties of glass would also assist in opening up new fields or markets which had heretofore been untouched, and considered outside of the domain of the glass manufacturer. A discussion followed.

PUBLICATION OF INTERNATIONAL CRITICAL TABLES

Numerical Data of Physics, Chemistry and Technology

Announced by the National Academy of Sciences and the National Research Council of the United States

In making the publication contract, the National Research Council has reserved to members of scientific and engineering societies, and to libraries and research laboratories, for a certain period, the right to purchase the volumes at the estimated manufacturing cost.

The work of compiling International Critical Tables was undertaken by the National Research Council at the request of the International Union of Pure and Applied Chemistry, with the endorsement of the International Union of Pure and Applied Physics, and under the auspices of the International Research Council.

The material contained in International Critical Tables has been collected and critically evaluated by some 300 Coöperating Experts, including chemists, physicists, and engineers of the United States, Canada, Great Britain, Belgium, France, Italy, Austria, Germany, Denmark, Switzerland, Holland, Australia and Japan.

The editorial expenses (about $170,000) have been contributed by American industrial firms and Benevolent Foundations. The work of the Coöperating Experts, which is practically gratuitous, may be assigned a money equivalent of not less than $300,000. The cost of printing and distribution will be about $100,000 and the whole undertaking represents a money value of at least $570,000, of which the returns from subscriptions will represent only a minor part.

The scope of the material collected covers all available information of value concerning the physical properties and numerical characteristics of (*a*) pure substances, (*b*) mixtures of definite composition, (*c*) the important classes of industrial materials, (*d*) many natural materials and products, and (*e*) selected data for selected bodies or systems, such as the earth and its main physical subdivisions and the solar and stellar systems. Publications of the world in all languages have been combed for data and much unpublished information has also been collected.

In addition to their wide scope, the tables will contain many novel features of arrangement. Thus, for example, not only will it be possible to find readily all of the properties of a given substance or material, but it will also be possible in many cases to

ascertain readily what substance or material of a given kind has a maximum, a minimum, or a given value for any given property. This feature will be of great assistance in identifying a substance by means of its properties or in selecting a substance or material on the basis of a given property or combination of properties.

The principal language employed will be English; but much of the explanatory text, the tables of contents, and the very complete index, will be given also in French, German and Italian.

The work will be issued in five volumes, comprising an estimated 2500 pages ($8^1/_2$ by 11 inches), and the Editors are making every effort to compress the material which has been collected into the available 2500 pages. All volumes will be bound in a uniform reinforced buckram binding, and will be delivered to all advance subscribers as issued, with packing and carriage charges prepaid.

In making the publication contract, the National Research Council reserved for scientific men the right to purchase International Critical Tables at a price which represents substantially only the cost of printing and distributing, on the following basis:

1. International Critical Tables will be published at the price of $60 for the five-volume set, at which price all orders placed directly with the publishers will be filled.

2. Until the appearance of Volume One (early in 1926) but not thereafter, the following classes of persons and institutions shall have the right to subscribe at the rate of $35 for the set of five volumes.

(*a*) Individuals who are members of a recognized scientific or technical society; but only one set may be subscribed for by one individual.

(*b*) Educational institutions, public libraries, government departments, research laboratories, and the libraries of industries. Such organizations may purchase a number of sets if required for their own use.

3. No order can be accepted from or through book dealers or agents at the pre-publication price.

CALENDAR OF CONVENTIONS

Organization	Date	Place
Amer. Assn. for Advancement of Science	Dec. 28–Jan. 2	Kansas City, Mo.
AMERICAN CERAMIC SOCIETY	Feb. 8–13, 1926	Atlanta, Ga.
American Chemical Society		
(Spring Meeting)	April 5–9, 1926	Tulsa, Okla.
American Concrete Institute	Feb. 23–26, 1926	Chicago, Ill.
Amer. Electrochemical Society	April 22–24, 1926	Chicago, Ill.
American Engineering Council	January, 1926	
American Face Brick Association	Dec. 1–3, 1925	Atlanta, Ga.
American Foundrymen's Assn.	Sept. 27, 1926	Detroit, Mich.
Amer. Institute of Chem. Engrs.	Dec. 2–5, 1925	Cincinnati, Ohio
Amer. Institute of Min. and Met. Engrs.	February 15, 1926	New York City
American Mining Congress		
(Annual Meeting)	Dec. 9–11, 1925	Washington, D. C.
Amer. Soc. Steel Treating	Jan. 21–22, 1926	Buffalo, N. Y.
Amer. Soc. Testing Materials	June 21–26, 1926	Atlantic City, N. J.
Amer. Zinc Institute	April 27–28, 1926	St. Louis, Mo.
Assn. Chemical Equipment Mfrs.	May 10–15, 1926	Cleveland, Ohio
Assn. Iron and Steel Mfrs.	May 31–June 5, 1926	Chicago, Ill.
Associated Tile Manufacturers	December 9, 1925	New York City

Organization	Date	Place
Baltimore-Washington Section (American Ceramic Society)	Dec. 5, 1925	Washington, D. C.
Canadian National Clay Products Association	Jan. 26–28, 1926	Toronto, Canada
Coal Mining Institute of America	Dec. 9–11, 1925	Pittsburgh,
Common Brick Manufacturers	February 22–26, 1926	New Orleans, La.
Grinding Wheel Mfrs. of U. S. and Canada	Dec. 11, 1925	Buffalo, N. Y.
Hollow Building Tile Assn.	January, 1926	Chicago, Ill.
Manufacturing Chemists' Association	May or June, 1926	Near New York City
Natl. Acad. of Sciences (Spring Meeting)	April 26–28, 1926	Washington, D. C.
Natl. Assn. of Mfrs. of Pressed and Blown Glassware	March 9, 1926	Pittsburgh, Pa.
Natl. Assn. Stove Mfrs.	May 12–13, 1926	New York City
Natl. Exposition of Power and Mechanical Engrs.	Nov. 30–Dec. 5, 1925	New York City
Natl. Exposition of Coal Mining Mach.	Dec. 2–5, 1925	Cincinnati, Ohio
Natl. Paving Brick Mfrs. Assn.	January, 1926	
Natl. Society Vocational Education	Dec. 3–5, 1925	Cleveland, Ohio
Natural Gas Assn. of America	May 17–20, 1926	Tulsa, Okla.
New Jersey Clayworkers' Assn.	Dec. 18, 1925	New Brunswick, N. J.
Sand-Lime Brick Assn.	Feb. 9–15, 1926	New Orleans, La.
Taylor Society	Dec. 3–5, 1925	New York City

Official Personnel of Divisions—1925-26

	Art	Enamel	Glass	Heavy Clay Products	Refractories	Terra Cotta	White Ware
Chairman	Mary G. Sheerer	M. E. Manson	A. Silverman	John D. Martin	C. E. Bales	E. C. Hill	F. H. Riddle
Vice-Chairman	Margaret K. Cable		Herbert Insley		R. F. Geller	W. J. Stephani	
Secretary	H. Clinton Baldwin	H. G. Wolfram	A. N. Finn	Amos P. Potts	L. C. Hewitt	G. M. Tucker	F. H. Rhead
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Committee on Standards							
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(*b*) Products	(*b*) F. H. Rhead		(*b*) A. E. Williams	(*b*) Hewitt Wilson	G. A. Bole	(*b*) W. L. Howat	(*b*) Robert Twells, Jr.
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Comm. on Coöperation			James Gillinder	J. L. Child	L. C. Hewitt	P. G. Larkin	R. F. Geller Perry Helser Stephen Leech
Committee on Contact			W. M. Clark	G. A. Bole		R. N. Long	
Editor: Question Box	Margaret K. Cable		R. R. Shively		E. E. Ayars	Hewitt Wilson	
Committee on Exhibitions	Martha G. Westfeldt	W. V. Knowles	A. R. Payne	B. Mifflin Hood		B. S. Radcliffe	
Trustee	Paul E. Cox	R. R. Danielson	J. C. Hostetter	C. Forrest Tefft	J. S. McDowell	R. L. Clare	C. C. Treischel

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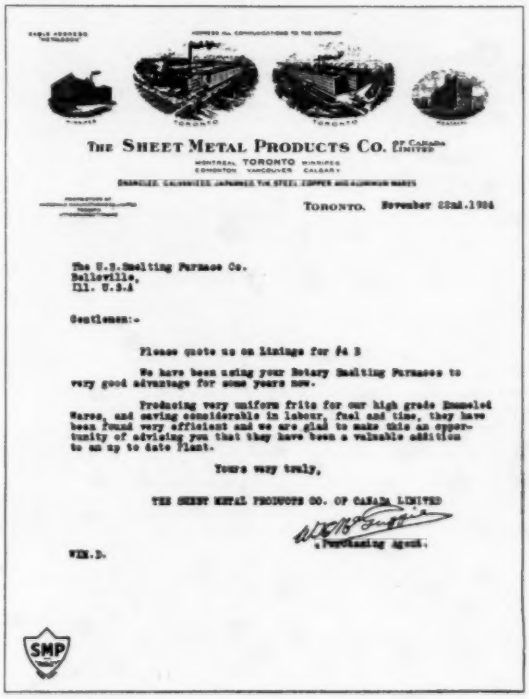

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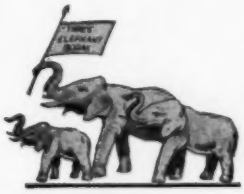

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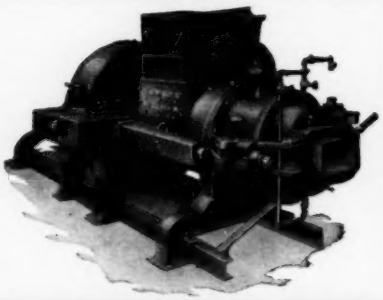

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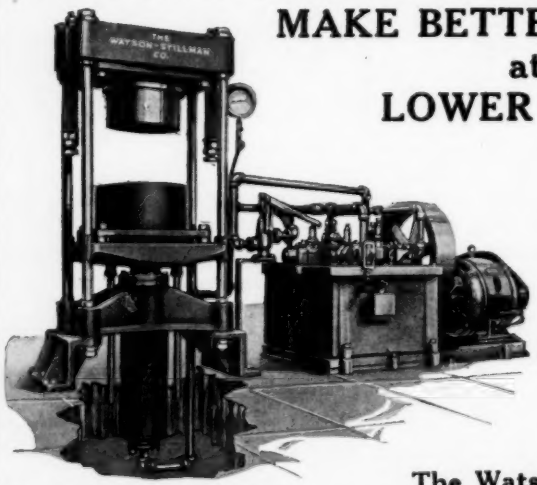

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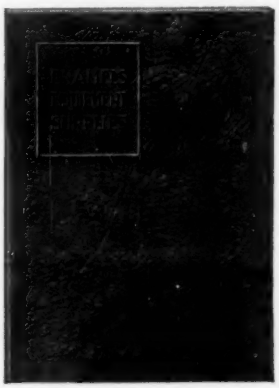

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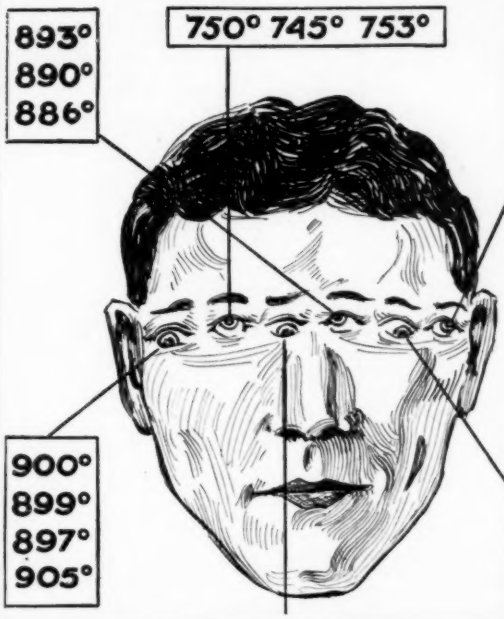

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The Brown Instrument Co. announces the opening of a Los Angeles Branch at 363 New High Street, Los Angeles, Calif., with Mr. S. F. Godfrey, late of The Braun Corporation, as District Manager.

Articles of incorporation having been filed in California, this branch will carry stock and conduct its own accounting direct with its customers. Users of Brown Pyrometers, Recording Thermometers, Electric CO_2 Meters, Electric SO_2 Meters, Pressure Gauges, Tachometers, Draft Gauges, etc., will appreciate this new Branch Office.

A complete Repair Department is maintained and customers are assured of thorough Brown Service in every way.

They also announce the opening of the following offices:
Indianapolis, Ind., 215 East New York St., Mr. J. R. Green, in charge.
Cleveland, Ohio, Room No. 1108 Hippodrome Building, Mr. G. S. Frazee, in charge.

THE WOLVERINE PORCELAIN ENAMELING COMPANY of Detroit, Michigan is planning further additions to the present plant.

Two furnaces, sixty inches wide by one hundred and eighty inches long and additional sand blast equipment will go into the new building which is being erected. Approximately One Hundred Thousand Dollars will be spent at this time.

The plant is operated under the management of the Porcelain Enamel and Manufacturing Company of Baltimore, Maryland, which company is successfully operating large plants in other cities throughout the United States.

Your inspector will see the profit

The enameled parts that pass his inspection bring back profits. There will be a great many more perfect pieces if you use Toncan.

The utmost care is used to prevent distortion in Rolling Toncan Sheets. They are slowly and thoroughly annealed to remove all chance of strains in the metal.

These precautions, and the natural stiffness of Toncan at high temperatures insure a minimum amount of warping and distortion in the fusing process.

Toncan is as free from internal defects as iron can be made. The surface is smooth, clean, slightly open. It grips the enamel firmly.

TONCAN METAL

Acquaint yourself with Toncan results in your own plant. We will be glad to cooperate.

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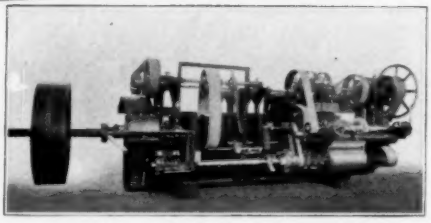

Reclaiming Abandoned Clay Banks

Limestone, lime pebbles and similar lumpy chemical impurities often constitute such a nuisance that entire clay deposits must be abandoned.
The Lancaster AutoClay cleaner now makes it possible to reclaim such workings. It turns stony clay into clay of excellent quality—free from limestone, pyrites and other lumpy impurities. It does the job in the *only right way*—by the *wet plastic method*. It is a sturdy machine, has great capacity and is quick and economical in operation.
Full particulars furnished on request.

Let Lancaster Engineers help solve your clay preparing problems.

LANCASTER IRON WORKS, Inc.
LANCASTER, PENNSYLVANIA
BRICK MACHINERY DEPARTMENT JAMES P. MARTIN, Manager

WABIK QUALITY M PRODUCTS METAL

After an exhaustive study of the requirements of the Enameling Industry we are producing:

WABIK METAL SPECIAL VITREOUS ENAMELING SHEETS

Unlike ordinary steel sheets, warping and blistering is reduced to a minimum, thus increasing the Enameler's output and profit.

Many of the leading plants now recognize "WABIK METAL" as the supreme stock for that beautiful permanent lustre which is so essential in Table Tops, Stove Parts, Refrigerator Parts, Signs, etc.

THE MANSFIELD SHEET & TIN PLATE CO.
MANSFIELD, OHIO

SERVICE TO POTTERS

We Manufacture—	*We Sell—*
PINS	BALL CLAY
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THIMBLES	WAD CLAY
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SAGGERS	BITSTONE
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TILE for Decorating kilns	IMPORTED PARIS WHITE

THE POTTERS SUPPLY COMPANY
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The National Silica Co.

OREGON, ILL.

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99.97% Pure Silica *140 Silk Lawn Test*

Twelve Carboradiant Furnaces are in the plant of The Wolff Mfg. Co., Chicago

Far Greater Efficiency
With Far Greater Economy

THE CARBORADIANT FURNACE

THE history of every Carboradiant Furnace installation has proved that here is an enameling furnace that gives a greater production of better burned ware at less operating costs.

It saves on fuel—it effects an economy of labor costs—it speeds up and increases production.

The Carboradiant Furnace has revolutionized enameling furnace practice.

This is the furnace that heats by radiation—there is no muffle.

It heats by radiation from the combustion chambers of Carbofrax built in at each side of the working chamber.

Perfect combustion takes place in the Carbofrax chambers—no gases, soot or smoke to cause spotted ware—

A clean, uniform heat from door to back is the result—a constant, steady heat under absolute control.

There is no other refractory that has the high heat conductivity of Carbofrax—the Carborundum Refractory.

Therefore, in the Carboradiant Furnace there is a uniform flow of uniformly distributed heat permitting the loading of the working chamber to fullest capacity. There are no "hot spots" in the Carboradiant.

Our Sales Engineering Department will gladly consult with you in the matter of a Carboradiant installation in your plant

CARBORUNDUM REFRACTORIES

Brick and Tile for Boiler and Furnace Settings; Muffles for Enameling Furnaces; Hearths for Heat-Treating Furnaces; Cements for all High Temperature Work

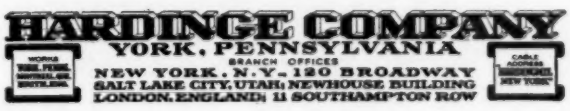
THE CARBORUNDUM COMPANY, PERTH AMBOY, N. J.

Grinding Problems?

Have You One?

If it is one of small quantity production, we recommend the Hardinge Conical Batch Mill.

For large quantity grinding, we recommend the Continuous Conical Mill. When equipped with air classifier, a product of any degree of fineness can be secured.



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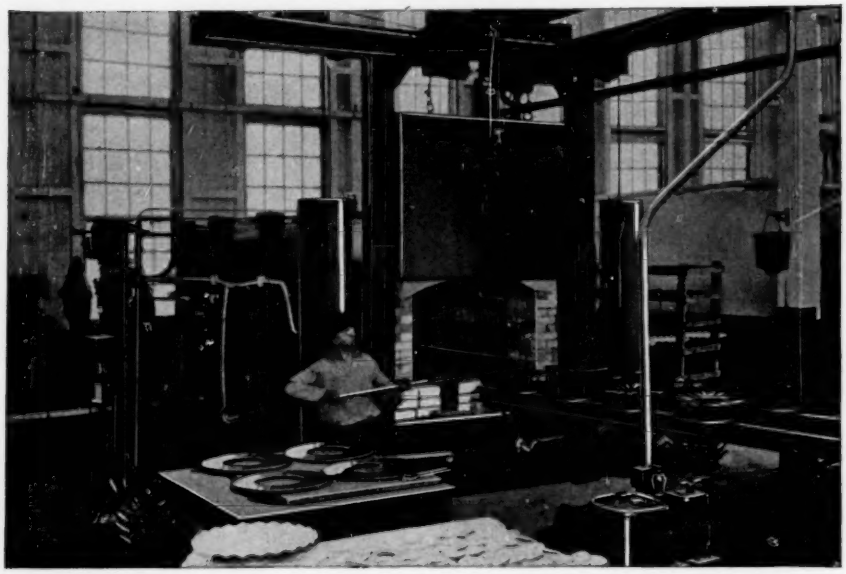

Electric vitreous enamel furnace equipped with G-E Direct-Heat Units and Automatic Temperature Control.

Electric Vitreous Enameling

Improving the product and reducing the cost of production are actual facts in the application of electric heat thru G-E Direct-Heat Units to vitreous enamel furnaces.

G-E Direct-Heat Units in your furnace mean no muffles to sag or break—no combustion gases and dirt—elimination of rejects due to spoilage by furnace—decreased labor for operating—and minimum upkeep on equipment.

G-E Direct-Heat Units radiate quick, clean heat direct to the charge—electric heat so uniformly distributed throughout the furnace, and so accurately controlled that the maximum speed and highest quality of vitreous enamel are obtained.

G-E Industrial Heating Specialists will gladly help you work out a better vitreous enamel furnace plan—through the proper application of electric heat.

General Electric Company
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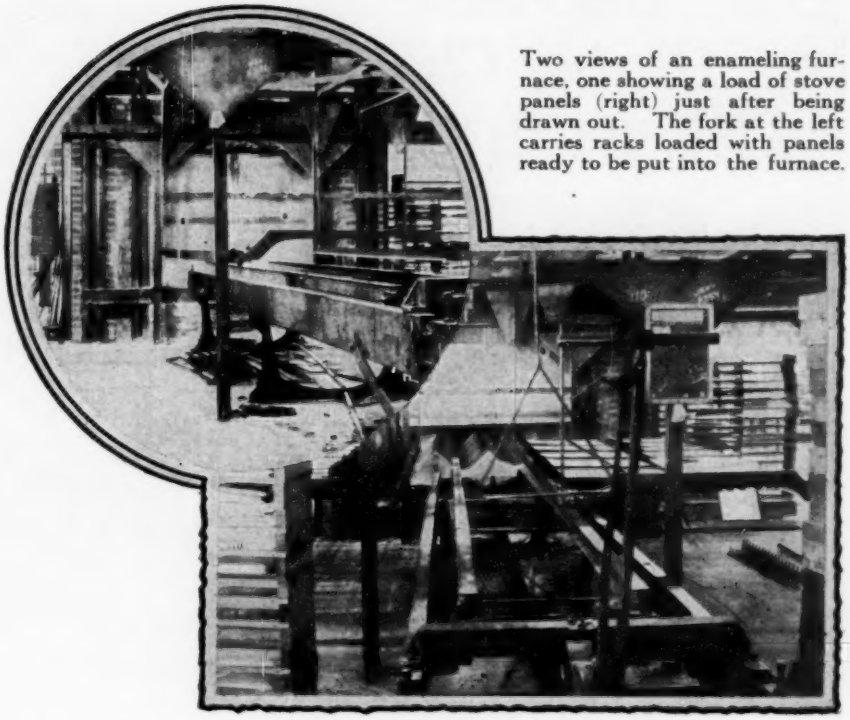

Two views of an enameling furnace, one showing a load of stove panels (right) just after being drawn out. The fork at the left carries racks loaded with panels ready to be put into the furnace.

ALUNDUM ENAMELING MUFFLES

Alundum is electrically fused alumina produced in an electric arc furnace. Alundum muffle plates are mechanically strong, chemically inert, have high heat conductivity, and are for these reasons ideally suited for the construction of enameling furnaces.

Repeat orders for Alundum muffles like the one in the furnace shown on this page are the best evidence of satisfactory performance.

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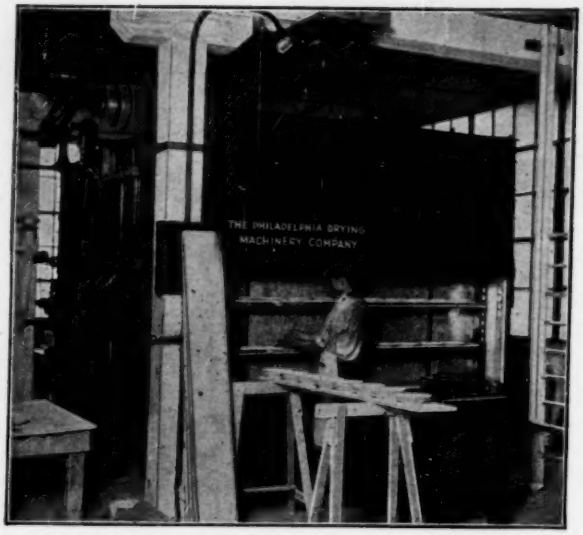
THE "HURRICANE" WAY



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What is the cost of your mounted porcelain enameled parts?

That is the basis on which to compare porcelain enamels.

It is the basis on which you have to sell and on which your costs are determined—So! It is the logical basis on which to buy.

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